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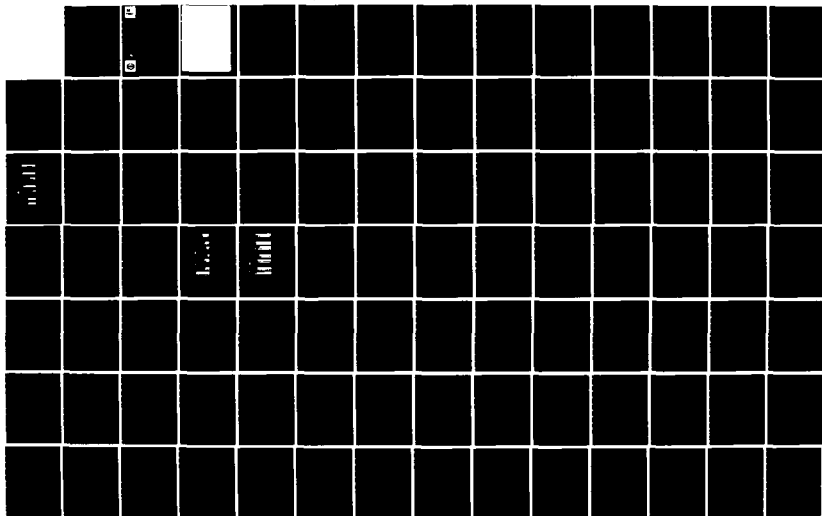
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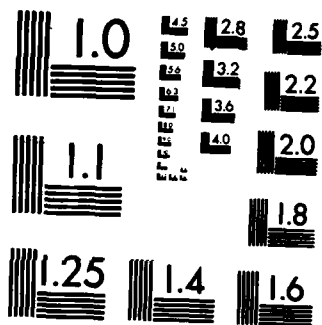
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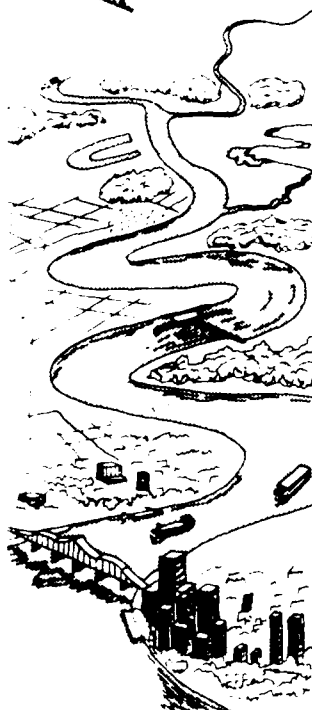






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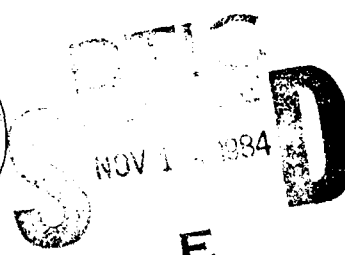
TECHNICAL REPORT E-84-9

FISH AND INVERTEBRATES OF
REVTMENTS AND OTHER HABITATS IN
THE WILLAMETTE RIVER, OREGON

by

Randy C. Hjort, Patrick L. Hulett,
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August 1984

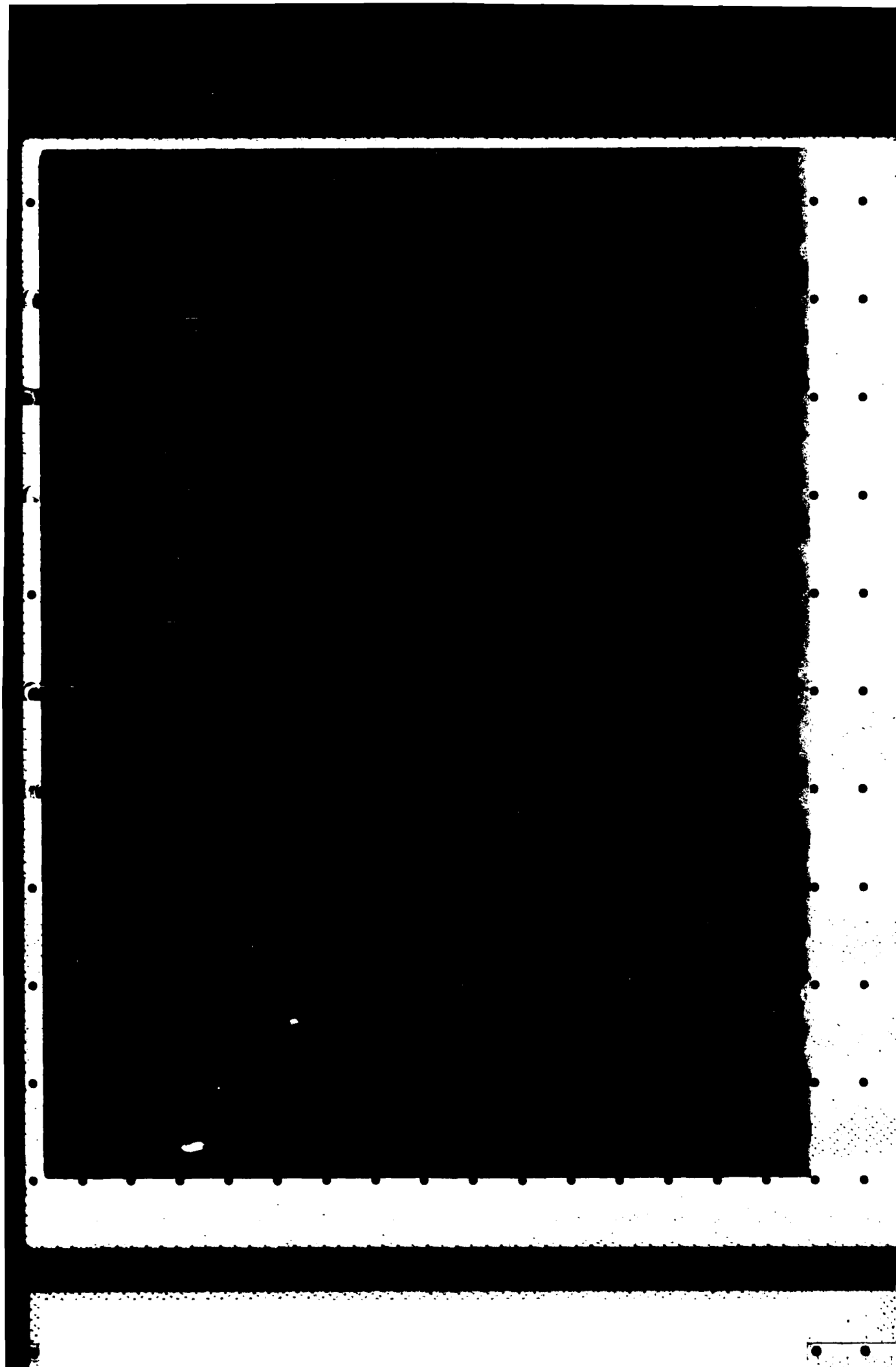
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) In this study, physical and biological parameters were compared at revetments and other aquatic habitats in the Willamette River below Salem, Oregon. The purpose was to determine if revetments affect the distribution and abundance of fishes and invertebrates, and to examine relationships between the physical parameters and the biological community. Sampling sites included two revetments, two natural banks, two side channels, and an abandoned channel. The study was conducted in 1982 at two flow levels. Sampling periods were June (Continued)		

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20. ABSTRACT (Continued).

when flows were moderate (283-425 m^3/sec) and August when flows were low (221-238 m^3/sec). The physical parameters included water quality indices (temperature, dissolved oxygen, pH, redox potential, turbidity, and conductivity), water velocity, and sediment analysis. The biological parameters were fish and invertebrate densities and fish weight.

During each study period, water quality indices were similar at all stations except for those in the abandoned channel, which was generally higher in water temperatures and conductivities and more variable in dissolved oxygen. Water temperatures and turbidities were higher during the August sampling period compared to June. Water current velocities were highest at the natural bank sites followed by the revetments and secondary channels. The abandoned channel had little or no water flowing through it.

Bottom types included large rocks at the revetments, silt and gravel mix in the abandoned channel, coarse gravel or sand at Five Island natural bank and the secondary channels depending on the water velocity, and silt and clay at Candiani natural bank where there was a severe erosion problem.

The species compositions of fishes and invertebrates were different among the habitats. Squawfish were the most abundant fish at the revetments and at Five Island secondary channel. largescale suckers were the most abundant at Candiani natural bank, Candiani secondary channel, and the abandoned channel, and leopard dace were the most abundant at Five Island natural bank.

Anisogammarus was the most abundant invertebrate at the revetments, while Oligochaetes were the most abundant at Candiani natural bank, Five Island secondary channel, and the abandoned channel. Chironomids were the most abundant invertebrate at Five Island natural bank and Candiani secondary channel. The densities of fish and invertebrates were generally highest at the revetments. The densities of fish were lowest in the secondary channels, and the densities of invertebrates were lowest at Candiani natural bank. The number of species and the species diversity were similar among the sampling sites. The total fish weight was highest at the abandoned channel, followed by Candiani secondary channel, Candiani natural bank, and the revetments.

Characteristics of the revetments include higher densities of fish and invertebrates; however, the species compositions at the revetments were different than those at the other habitats. Revetments offer stability of substrate and protective cover for organisms during high flows.

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PREFACE

The study described in this report was conducted by the Oregon Cooperative Fishery Research Unit (OCFRU) at Oregon State University (OSU), Corvallis, Oregon, for the U. S. Army Engineer Waterways Experiment Station (WES) under Intra-Army Order No. WESRF-82-106. This study is part of the Environmental and Water Quality Operational Studies (EWQOS), sponsored by the Office, Chief of Engineers (OCE), and assigned to WES under the management of the Environmental Laboratory. The OCE Technical Monitors for EWQOS were Dr. John Bushman, Mr. Earl Eiker, and Mr. James L. Gottesman.

This report presents the results of a study designed to determine the impact of stone revetments on the distribution and abundance of fishes and benthic invertebrates of the lower Willamette River between river miles 58 and 66. The study periods were in June and August of 1982.

The report was prepared by Mr. Randy C. Hjort, Mr. Patrick L. Hulett, Mr. Larry D. LaBolle, and Dr. Hiram W. Li of OCFRU. Mr. Dave Nelson (WES) administered the study, and Dr. C. H. Pennington (WES) developed the sampling scheme. Mr. Dale McCullough (OSU) designed the sampling gear for the benthic invertebrates and helped collect field samples. Dr. Charles Hawkins (OSU) and Mr. Randy Wildman (OCFRU) identified the benthic invertebrates. Dr. Peter Klingeman and Mr. Jeffrey Pike of the Water Resources Research Institute (OSU) analyzed the sediment samples. Program Manager of EWQOS was Dr. J. L. Mahloch (WES).

Special appreciation is expressed to Ms. Adrian Hunter who typed the manuscript, Miss LaVon Mauer who prepared the tables, and Dr. Stan Gregory who helped analyze the distribution of benthic invertebrates.

Commander and Director of WES during the study and preparation of this report was COL Tilford C. Creel, CE. The Technical Director was Mr. F. R. Brown.

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CONTENTS

	<u>Page</u>
PREFACE	1
PART I: INTRODUCTION	4
PART II: METHODS AND MATERIALS	6
Sampling Periods and Locations.	6
Sampling Techniques	6
Statistical Analysis.	14
PART III: RESULTS.	16
Sediments	16
Water Quality	17
Fish	21
Benthic Invertebrates	39
PART IV: DISCUSSION.	59
Habitat Characteristics	59
Physical and Water Quality Characteristics.	60
Distributional Patterns of Aquatic Organisms.	60
Physical Impacts at Revetments.	67
Individual Fish Species Distributions	71
Patterns of Invertebrate Taxa Distribution.	71
Comparisons with Past Studies	71
PART V: SUMMARY.	73
REFERENCES.	74
BIBLIOGRAPHY.	77
APPENDIX A: FISH CATCHES FROM ELECTROSHOCKING AND HOOPNET SETS ON RIVER MILES 58-66 OF THE WILLAMETTE RIVER, OREGON, JUNE AND AUGUST 1982	A1
APPENDIX B: BENTHIC INVERTEBRATE DENSITIES FROM SAMPLES COLLECTED FROM RIVER MILES 58-66 OF THE WILLAMETTE RIVER, OREGON, JUNE AND AUGUST 1982	B1
APPENDIX C: SEDIMENT SAMPLE ANALYSES	C1

FISH AND INVERTEBRATES OF REVETMENTS AND OTHER HABITATS
IN THE WILLAMETTE RIVER, OREGON

PART I: INTRODUCTION

1. Stone revetments have been used extensively on the Willamette River to stabilize the streambanks and channels. The revetments are placed at eroding banks to prevent channel changes and the loss of land, thus protecting farmland, buildings, roads, and utilities. The first revetment on the Willamette River was installed in 1888, and since that time a variety of bank stabilization techniques have been tried (Thorner 1965; Thorner and Bubenik, undated). The Army Corps of Engineers has been responsible for the construction and the evaluation of the revetments on the Willamette River (U. S. Army Corps of Engineers 1975) and has sponsored studies to evaluate alternatives and supplements to riprap revetments (Klingeman and Bradley 1976; Bierly and Assoc. 1980).

2. Extensive bibliographies have been compiled for streambank protection techniques (Keown et al. 1977) and their effects (Stern and Stern 1980). Information on riprap-type revetments and their biological impact is more limited, and the conclusions vary among stream systems. The physical effects of revetments on streams range from little apparent impact (Bulkley et al. 1976) to actually changing the stream morphology and reducing habitat diversity for aquatic organisms (Johnson et al. 1974; Funk and Robinson 1974). Other effects include reduction of the riparian vegetation, which affects both terrestrial and aquatic organisms (U. S. Fish and Wildlife Service 1976) and possible degradation of the streambed (Klingeman 1973). Revetments are believed to benefit invertebrates by stabilizing bank habitat so that invertebrates can become established (Johnson et al. 1974; Solomon et al. 1975; Menzel and Fierstine 1976); however, in some cases, revetted sections of stream have lower fish production or standing crops than nonrevetted sections (Bianchi and Marcoux 1975; Peters and Alvord 1963).

3. The Willamette River has experienced a dramatic change during the past 20 years. An extensive cleanup program (Gleeson 1972; Starbird 1972; Council on Environmental Quality 1973), an upstream reservoir system (Shearman 1976), and a proposed Willamette River Greenway System have changed the purpose of the river from a conveyer of industrial and municipal sewage

(Gleeson and Merryfield 1936; Westgarth and Northcraft 1964; Britton 1965) to a recreational and environmental asset (Willamette Basin Task Force 1969; Hansen 1977; Deval 1977).

4. The number and size of the Willamette River revetments impact the physical and biological characteristics of the streambanks. Physical impacts include changes in shoreline substrate type, shoreline gradient, and water velocity. These physical changes may affect the distribution and abundance of fishes and benthic invertebrates in the Willamette River.

5. This study was designed to address the following objectives regarding the physical and biological impacts of revetments.

- a. To determine whether there are differences in the distribution and abundance of fishes and benthic invertebrates between revetted and nonrevetted banks on the Willamette River below Salem, Oregon.
- b. To quantitatively describe certain physical characteristics of revetted and nonrevetted banks of the river.
- c. To correlate changes in invertebrate and fish densities with differences in physical habitat.
- d. To compare the composition of different functional groups of fishes and invertebrates in different environmental settings.

PART II: METHODS AND MATERIALS

Sampling Periods and Locations

6. This study was conducted on the Willamette River at two different flow levels: during 8-18 June when the flows were at moderate levels (283-425 m³/sec) and during 16-25 August when the flows were lower (221-238 m³/sec).

7. Seven locations between river miles 58 and 66 of the Willamette River, Oregon were sampled (Figure 1). These locations were distributed among four habitat types: two revetted banks--banks on the outside bends of the main river channel stabilized by stone (riprap) revetments (Figures 2,3); two natural banks--nonrevetted banks of the main channel (Figure 5)--one actively eroding, one apparently stable (Figure 4); two secondary channels--shallow, narrow channels that run parallel to the main river channel (Figures 4,5); and one abandoned channel--an old channel, still connected to the main river channel but carrying no flow during the study period (Figure 6). In each location four stations were marked along the shoreline at 152-m intervals. These stations were used to determine sites for fish sampling, substrate sampling, and measurement of chemical and physical water parameters.

Sampling Techniques

Fish

8. A boat electroshocker and hoopnets were used to sample the fish from each location. The electroshocking boat pulsed direct current at 120 cycles/second, through boom-mounted anodes with the boat hull serving as the cathode. Traveling downstream, samples were taken close to shore along three 152-m transects between the four stations at each of the seven locations. Thus, 21 transects were sampled for each of the two sampling periods. Data obtained for each transect were recorded separately. The amperage, voltage, and pulse width were standardized on a test run and the same settings were used for all locations where conductivities were similar. The voltage was decreased in areas of high conductivity and increased in areas of low conductivity to maximize the amperage.

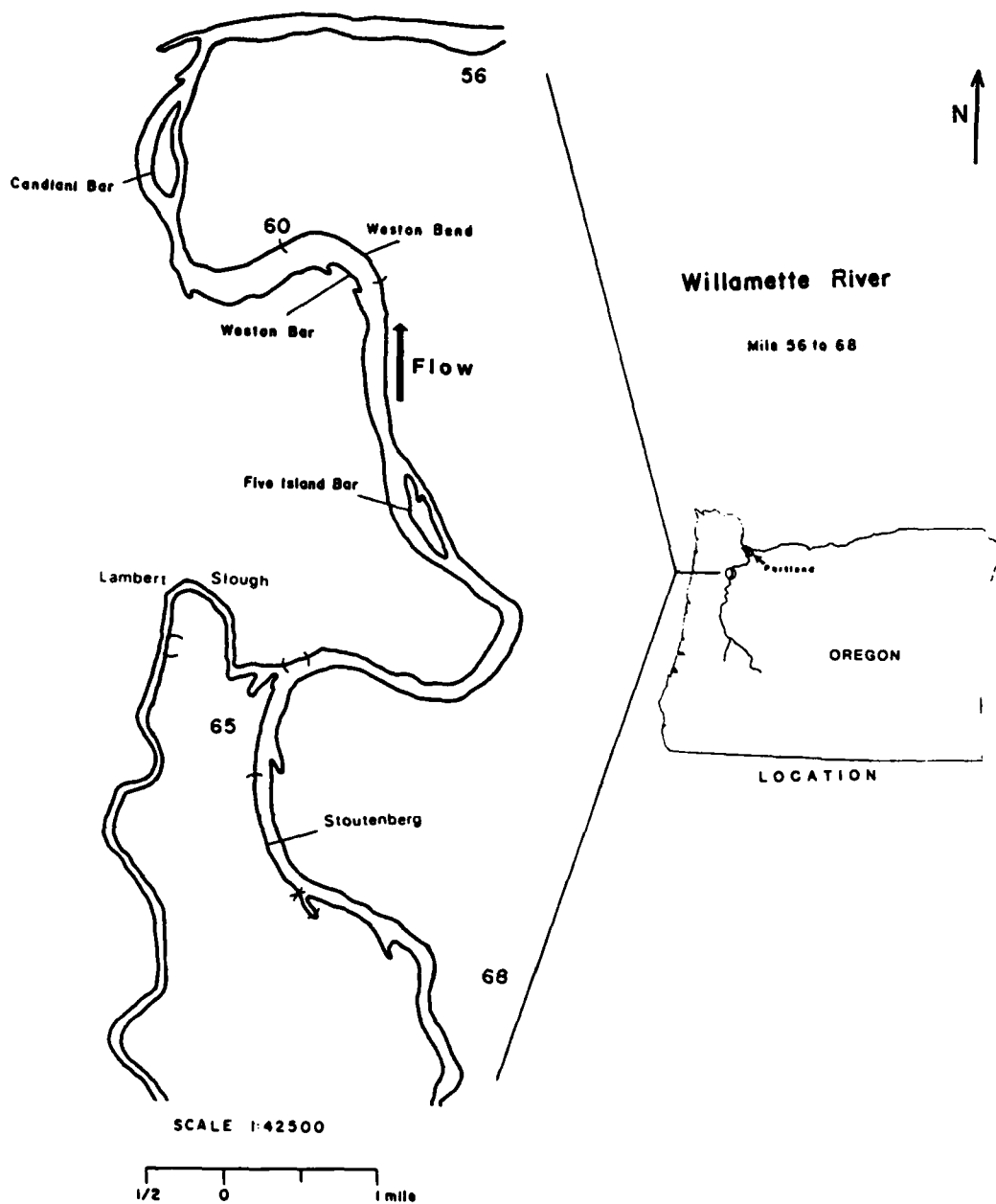


Figure 1. Map illustrating the sampling locations within the study area on the Willamette River, Oregon

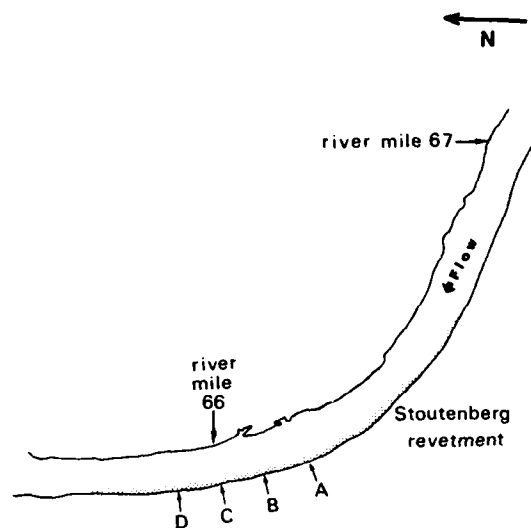


Figure 2. Map illustrating the Stoutenberg revetment sampling location. (Stippling indicates revetted bank; letters A-D represent the sampling stations)

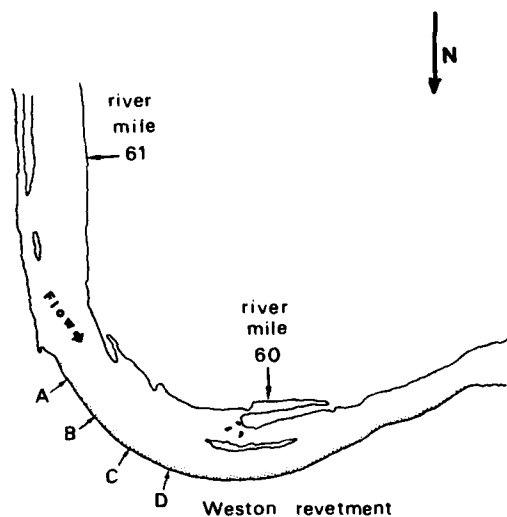


Figure 3. Map illustrating the Weston revetment sampling location. (Stippling indicates revetted bank; letters A-D represent the sampling stations)

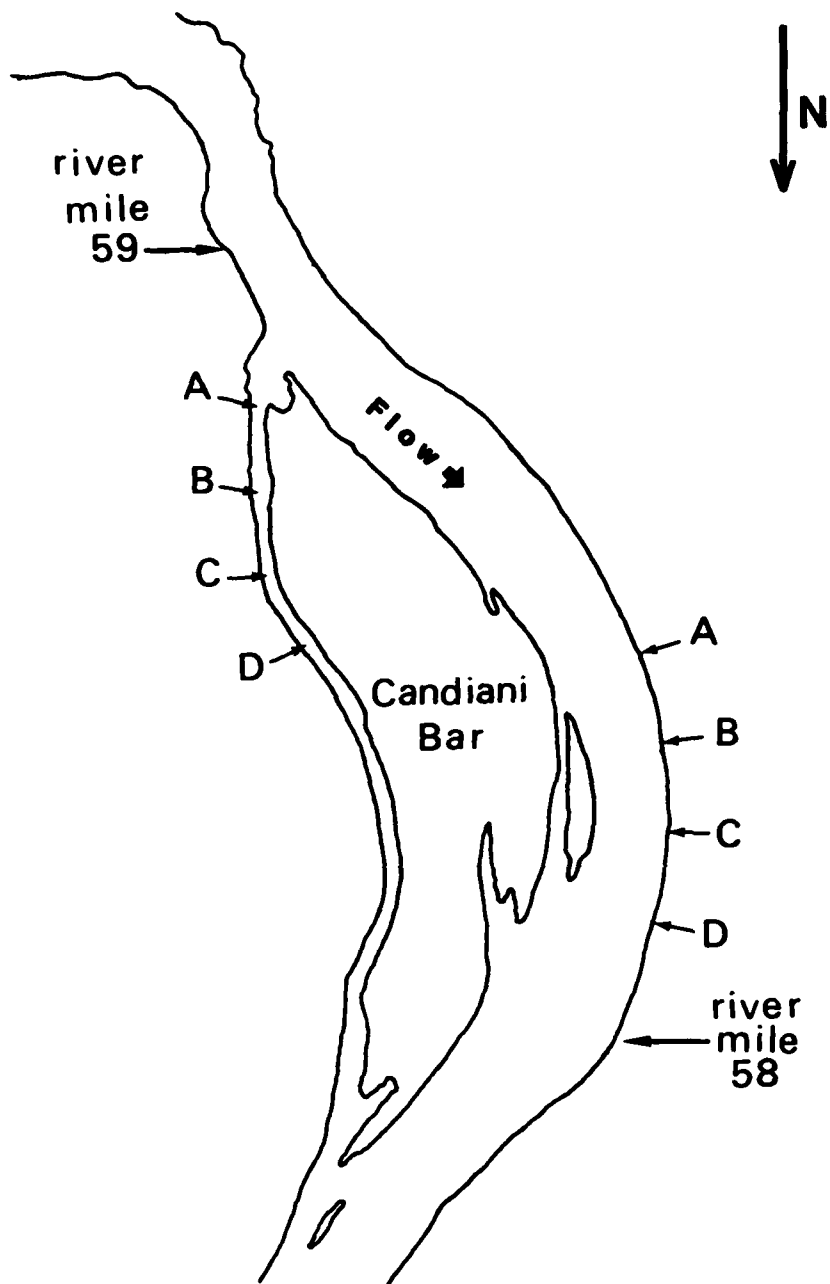


Figure 4. Map illustrating the Candiani Bar natural bank (right) and secondary channel (left) sampling locations. (Letters A-D indicate the sampling stations)

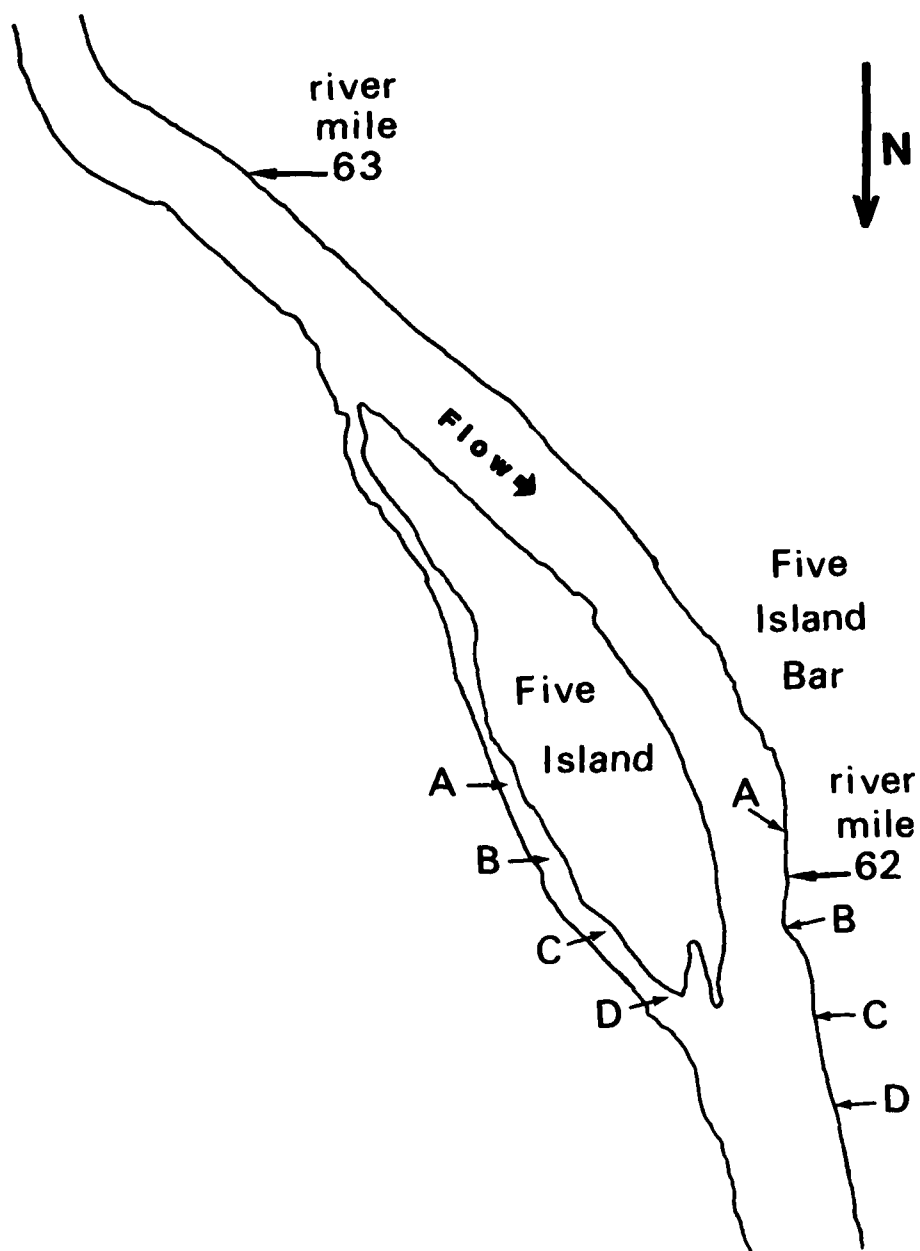


Figure 5. Map illustrating the Five Island Bar natural bank (right) and secondary channel (left) sampling locations. (Letters A-D indicate the sampling stations)

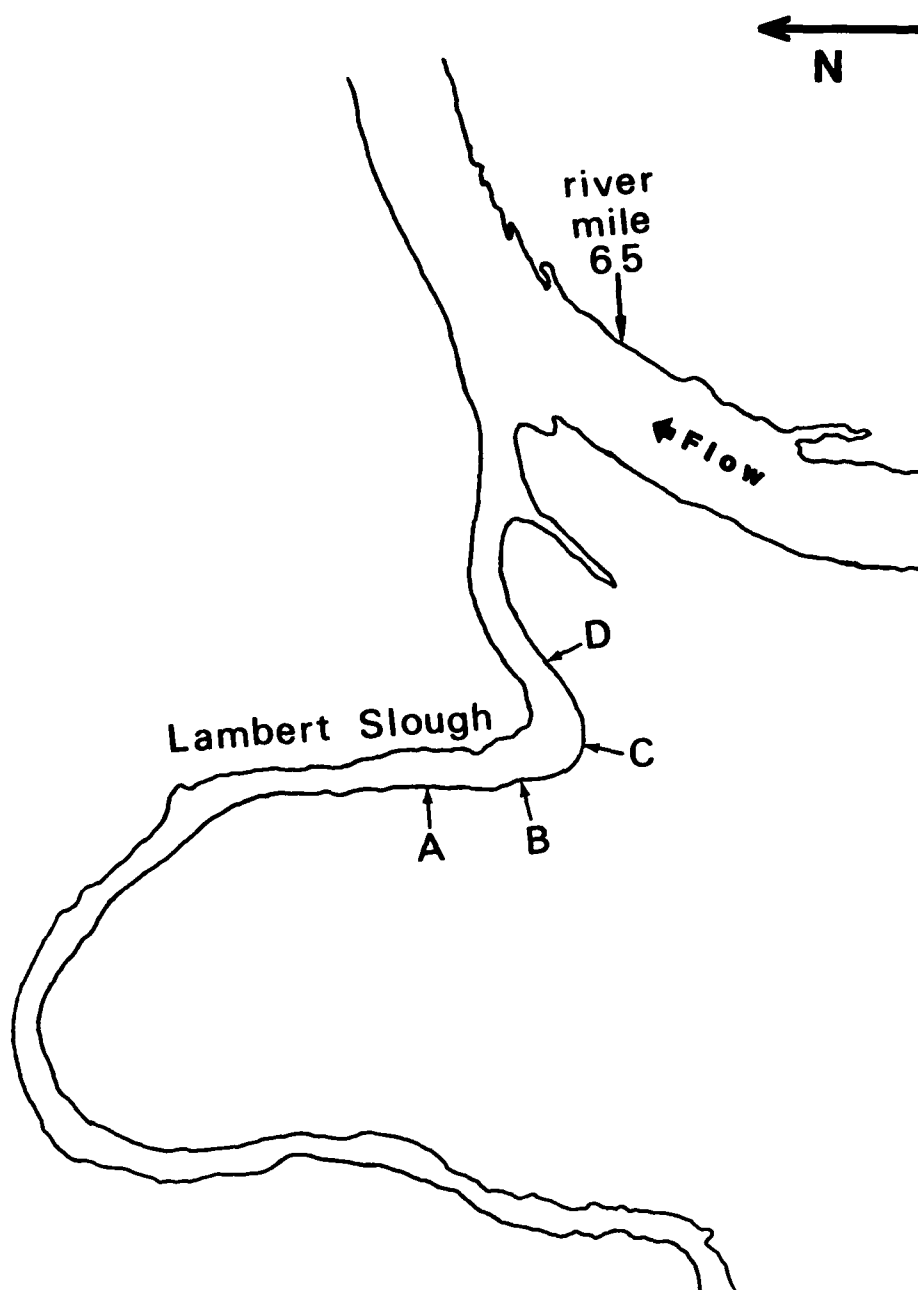


Figure 6. Map illustrating the Lambert Slough abandoned channel sampling location. (Letters A-D indicate the sampling stations)

9. The hoopnets, constructed of 2.5-cm-square mesh, were 4.6-m long with seven 0.9-m hoops and two throats, located at hoops 2 and 4. The nets were set, unbaited, facing downstream at each of the four stations in each location for two consecutive 24-hour periods. Thus, 56 hoopnet sets were sampled in each of the two sampling periods.

10. For each shocking transect and hoopnet set, each fish was identified to species using keys prepared by Bond (1973) or Wydoski and Whitney (1979). Total lengths (millimetres) and weights (grams) were recorded. Specimens which were difficult to identify were preserved for later identification.

Benthic Invertebrates

11. The benthic invertebrates were sampled at each revetted station midway between the waterline and the toe of the revetment, and at a similar position in the natural habitats. One of two methods was employed to collect the samples, depending on the substrate size and water velocity at each station. A glove-box sampler (Figure 7) was placed on the bottom, and the substrate was scooped into an attached collection bag at all nonrevetted sites with moderate or high water velocity. At stations with low water velocity, the smaller substrate was pumped to the surface by a venturi-type dredge and sieved through a 0.3-mm mesh. At the revetted stations, the surface and crevices of the substrate were vacuumed and the smaller riprap material to be cleaned of organisms at the surface was removed. Two replicates were collected to a depth of 27 cm at each station and combined into one sample. The total area of the two replicates equaled a 0.5- x 0.5-m quadrat. The samples were preserved in 10% formalin, and the date, time, depth, water velocity, location, and station were recorded.

12. Before sorting, the samples were sieved through 0.5-mm mesh, transferred to 70% ethanol, stained with Rose Bengal solution, and subsampled using settling tubes as described by Mundie (1971). One of two subsamplers was used, depending on the volume of the samples. For large samples, a 19-l bucket (277-mm diameter) was used with 200 test tubes, each with a mouth area of 1/365 of the bucket's total cross-sectional area. For small samples, a 120-mm-diam container, with 24 test tubes each with a mouth area of 1/50 of the cross-sectional area of the container, was used. The organisms were sorted using variable-power dissecting scopes (8-40x). Identification was to the generic level.

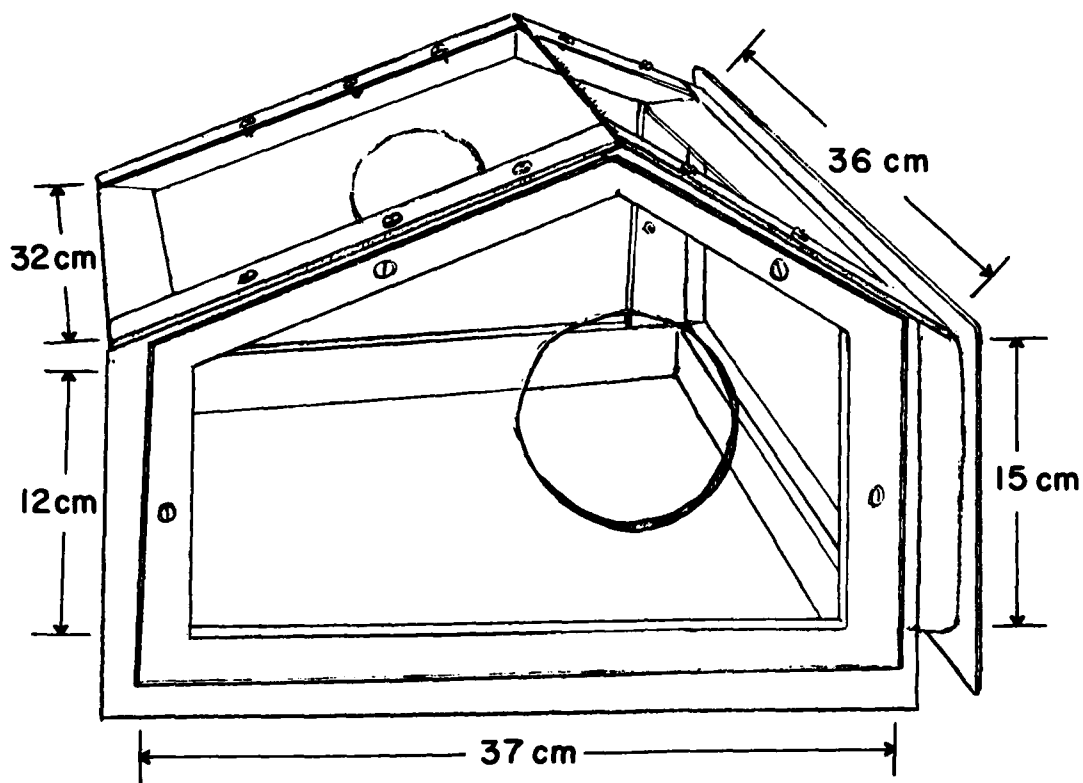


Figure 7. Design of glove-box sampler for collection of benthic invertebrates in flowing water. Frame is of heavy-gage steel bars and angle iron. Plexiglass panels cover top and side surfaces. Bottom, front, and rear are open. A bag attaches over the rear opening (15 x 36 cm), collecting benthos carried by current that enters through the front opening (12 x 32 cm). Reaching through arm ports (10-cm-diam) in side panels, operator scoops substrate into collection bag from area defined by bottom opening (12 cm wide in front, 37 cm long and 15 cm wide in rear = $1/8 \text{ m}^2$), digging to desired sample depth

Physical and Chemical

13. The stations at which samples for identifying sediment type were taken corresponded with those of the benthic invertebrate samples. Sediment samples were collected only during the first sampling period. The samples were analyzed for grain size according to Engineer Manual 1100-2-1906 (Department of the Army 1970).

14. The physical and chemical water parameters were measured in each habitat at dawn and dusk of the first and last sampling days for each sampling period. A calibrated Hydrolab multiparameter, in situ water analysis system (Model No. 8100) was used to measure the following:
a) temperature in °C to the nearest tenth; b) dissolved oxygen in milligrams/liter; c) acidity in pH units to the nearest tenth; d) specific conductance in micromhos/square centimetre at 25°C to the nearest micromho; and e) redox potential in millivolts. An Endeco current meter was calibrated and used to determine the water velocity. Readings were recorded at 1 m below the surface, mid-depth, and 1 m above the substrate for stations with a depth greater than 3 m. For shallower stations, the readings were taken at shorter depth intervals or at a single depth. The latter case applied to all stations in August when water levels were lower.

15. Turbidity measurements were taken with a Hach laboratory turbidimeter, and the date, time, and water depth at each set of data were recorded. In addition, the water velocity and depth were recorded at each station for the hoopnet and benthic invertebrate samples. To estimate the average water velocity for each 152-m electroshocking transect, the water velocity values at the start and finish of each transect were averaged.

Statistical Analysis

16. Analysis of covariance on the abundance and weight per unit effort of each fish species and the abundance of benthic invertebrates was used to determine if significant differences existed among the locations. The 5% significance level was used in all analyses. The units of effort were 152-m transects for the electroshocker, 24-hour soak time for the hoopnets, and the 0.5-m-square sample for the benthic invertebrates.

17. Two important variates distinguishing locations were bottom type and water velocity. Water velocity was highly variable within locations, whereas substrate composition was relatively homogeneous. The analysis of covariance described the influence of location (and therefore substrate composition) and water velocity on the abundance/weight of fishes/invertebrates.

18. Three types of tests were performed using the analysis of covariance: a) a one-way analysis of variance to determine whether or not differences in abundance or weight of fishes or invertebrates significantly varied among locations; b) a correlation analysis between abundances/weights of fishes/invertebrates, and the covariate water velocity; and c) another one-way analysis of variance, this time using the abundances/weights of fishes/invertebrates that were adjusted for water velocity before comparisons were made among locations.

19. To determine if there were statistically significant differences between the sampling periods for abundance and weight, a completely randomized block analysis of variance, at the 5% significance level, was used. The blocks were the locations and the treatments were the sampling periods. Each gear type was analyzed separately and the differences were examined using Duncan's new multiple range test. The fish catch per unit efforts were transformed to ensure normality by using $\text{Log}_{10}(x+1)$ (Green 1979).

20. The Jaccard similarity coefficient was used to compare the similarity of fish species composition and the similarity of the benthic invertebrate samples among the different locations for each sampling period. The fish and benthic invertebrate diversities at each habitat type and for each sampling period were compared using the Shannon diversity index: $H' = -\sum p_i \log_{10} p_i$ where p_i is the proportion of each species or taxa. Electroshocking data were used to derive estimates of species composition and the Shannon diversity index (H'), while data from both collecting gears were used separately for statistical tests for differences in catch among locations. Data from both gears were combined to determine the Jaccard similarity index and species richness at each location. The fish catch and weight data from electroshocking and the hoopnets are presented in Appendix A, and the benthic invertebrate data are presented in Appendix B.

PART III: RESULTS

Sediments

Revetments

21. The Stoutenberg and Weston revetments were both constructed of irregularly shaped rocks, commonly called riprap, which were approximately 0.1 to 1.0 m in diameter. Numerous interstitial spaces were present. The bottom sediments in these habitats were not analyzed because most of the substrate was the large rock and there was very little sediment in the interstitial spaces.

Natural Banks

22. The substrates were similar among different stations of the natural bank at Five Island. The sediments were composed primarily of coarse and fine gravel and small amounts of fine sand (Appendix C). Station C had the lowest proportion of fine sand of the four stations because of its higher water velocity. Five Island natural bank appeared to be the most stable of the two natural bank locations in the study, with little or no erosion taking place during the study period.

23. The natural bank at Candiani Bar had a steep soil bank that eroded extensively before and during the study period. As a result, sediment samples consisted of fine sands and silt or clay (Appendix C). Indications that large portions of the bank were sloughing into the river were observed (localized high turbidity in the river, freshly exposed soil on the bank, and clumps of terrestrial grasses in the water).

Secondary Channels

24. Substrate samples from seven of the eight stations in the two secondary channels were 60-85% coarse and fine gravels, the remainder consisting of fine sand (Appendix C). The exception to this pattern was station D at Five Island, the substrate of which was comprised of 40% gravels and 60% fine sands. The water depth at this station was 1 to 2 m and there was little or no water current at the time of the study.

Abandoned Channel

25. The four stations in Lambert Slough were of two distinct sediment types. Sediments of the two stations farthest from the main channel, stations A and B, were fine sands and silt or clay (Appendix C). The highest proportion of organic material was found at these two stations. Sediments of the two stations closest to the river were dominated by coarse and fine gravels with some fine sands.

Water Quality

Revetments, Natural Banks, and Secondary Channels

26. Measurements of water quality were similar among locations in the main channel and secondary channels during the course of the study (Tables 1 and 2). Major trends include an increase in temperature, dissolved oxygen and pH from dawn to dusk, and an increase in water temperature from the beginning of the sampling period to the end. Water temperature and turbidity both increased from June to August. The parameters of water quality in June ranged as follows: temperature (14.0-20.3° C), dissolved oxygen (7.9-10.8 mg/l), conductivity (69-75 μ hos), pH (6.7-7.7), oxidation-reduction potential (283-318 mv), and turbidity (0.8-1.7 NTU). In August the values were: temperature (17.7-21.5° C), dissolved oxygen (7.5-9.7 mg/l), conductivity (76-83 μ hos), pH (6.7-7.4), oxidation-reduction potential (220-323 mv), and turbidity (0.9-3.8 NTU).

27. Water current velocities ranged from 0 to 123 cm/sec (Table 3). The highest average velocities were recorded at the natural bank locations, while the revetments and secondary channels were lower. Both secondary channels had a station with no current because they were located at deep pools. Average velocities decreased from June to August at all locations except the natural bank at Five Island and at the Candiani secondary channel where the velocities increased. The increase in August was due to a change in the sampling location, as lower water levels necessitated shifting the sampling site closer to the center of the stream.

Table 1. Physical variables recorded at station B of seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 8-18, 1982. Variables were recorded at three depths in Lambert Slough: 1 meter below the surface (1), midway between the surface and the bottom (2), and 1 meter above the bottom (3).

Variable (unit)	Date	Time	Bavetted Banks		Natural Banks		Secondary Channels		Abandoned Channel		
			Scoutenberg	Weston Bend	Five Island Mar	Candiani Bar	Five Island Mar	Candiani Bar	Lambert Slough		
Sample Depth (m)	6-8	Dawn	0.6	1.1	0.5	1.1	0.5	0.5	0.6	1.2	-
		Dusk	0.9	1.1	0.5	0.9	0.5	0.5	1.0	2.0	3.0
Temperature (°C)	6-18	Dawn	0.6	0.8	0.5	1.2	0.5	0.8	0.9	1.4	2.4
		Dusk	0.6	0.9	0.5	0.9	0.5	0.8	0.9	1.4	2.1
Dissolved Oxygen (mg/l)	6-8	Dawn	14.2	14.1	14.0	14.2	14.0	14.1	15.7	15.1	-
		Dusk	15.0	15.0	15.0	15.0	15.1	15.0	15.3	14.7	14.4
Conductivity (µmho)	6-18	Dawn	18.0	18.2	18.4	18.4	18.2	18.4	19.5	17.6	17.3
		Dusk	20.3	20.2	20.2	20.2	20.2	20.2	21.0	19.0	17.7
pH	6-8	Dawn	9.5	9.8	10.1	9.6	9.8	9.9	10.1	10.4	-
		Dusk	10.7	10.5	10.6	10.7	10.6	10.8	10.6	7.6	4.6
Oxidation-Reduction Potential (mv)	6-18	Dawn	8.4	7.9	8.0	8.4	8.3	8.2	10.5	10.0	9.8
		Dusk	8.9	8.7	8.6	8.9	8.9	9.1	15.1	11.8	10.9
Current Velocity (cm/sec)	6-8	Dawn	72	74	74	75	73	74	132	130	-
		Dusk	73	75	74	74	74	74	123	109	105
Turbidity (NTU)	6-18	Dawn	70	70	71	71	70	70	115	120	124
		Dusk	69	70	70	70	70	69	118	95	123
Oxidation-Reduction Potential (mv)	6-8	Dawn	7.2	7.1	7.2	7.2	7.2	7.2	6.8	6.6	-
		Dusk	7.7	7.6	7.6	7.6	7.6	7.6	8.8	6.6	6.4
Current Velocity (cm/sec)	6-18	Dawn	6.8	6.8	6.7	6.7	6.8	6.7	6.9	6.6	6.5
		Dusk	7.2	7.1	7.0	7.1	7.2	7.2	7.1	7.4	6.6
Oxidation-Reduction Potential (mv)	6-8	Dawn	283	315	301	314	313	301	266	220	-
		Dusk	291	304	318	300	316	297	333	335	339
Current Velocity (cm/sec)	6-18	Dawn	295	305	303	312	304	313	312	319	316
		Dusk	288	289	291	288	284	285	287	288	313
Current Velocity (cm/sec)	6-8	Dawn	108	83	108	103	77	83	0	0	-
		Dusk	93	82	83	139	98	103	0	0	0
Turbidity (NTU)	6-18	Dawn	72	62	62	93	83	103	0	0	0
		Dusk	57	57	72	93	82	93	0	0	0
Turbidity (NTU)	6-8	Dawn	0.8	1.3	1.2	1.3	0.8	1.1	1.4	-	-
		Dusk	1.2	1.3	1.2	1.3	1.3	1.2	1.8	-	-
Turbidity (NTU)	6-18	Dawn	1.3	1.3	1.3	1.5	1.3	1.4	1.4	-	-
		Dusk	1.4	1.3	1.5	1.7	1.4	1.2	1.9	-	-

Table 2. Physical variables recorded at station B of seven locations between river miles 58 and 66 on the Willamette River, Oregon, August 16-25, 1982.

Variable (unit)	Date	Time	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
			Skoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Sample Depth (m)	8-16	Dawn	0.9	0.9	0.4	0.9	0.6	0.6	0.9
		Dusk	0.9	0.9	0.6	0.9	0.6	0.6	0.9
	8-25	Dawn	0.6	0.9	0.5	0.9	0.9	0.6	0.9
		Dusk	0.9	0.9	0.6	0.9	0.9	0.6	0.9
Temperature (°C)	8-16	Dawn	17.7	17.9	17.8	18.1	17.8	18.0	19.4
		Dusk	19.5	19.5	19.5	19.5	19.5	19.6	22.2
	8-25	Dawn	19.7	19.8	19.7	20.0	19.8	20.0	23.1
		Dusk	21.5	21.3	21.3	21.2	21.3	21.3	23.2
Dissolved Oxygen (mg/l)	8-16	Dawn	8.3	8.2	8.4	8.5	8.6	8.3	8.2
		Dusk	8.8	9.1	9.4	9.3	9.6	9.7	9.6
	8-25	Dawn	8.4	7.9	8.2	7.7	8.2	7.5	9.0
		Dusk	8.7	8.6	8.8	9.2	8.7	8.6	9.8
Conductivity (umho)	8-16	Dawn	80	81	80	81	79	80	125
		Dusk	81	82	82	82	83	82	130
	8-25	Dawn	76	76	76	76	76	76	118
		Dusk	78	78	78	77	77	77	116
pH	8-16	Dawn	6.8	6.8	6.7	6.8	6.8	6.8	6.6
		Dusk	7.3	7.2	7.3	7.3	7.3	7.3	7.0
	8-25	Dawn	6.9	6.8	6.8	6.7	6.8	6.8	6.9
		Dusk	7.4	7.3	7.3	7.3	7.4	7.3	7.3
Oxidation-Reduction Potential (mv)	8-16	Dawn	291	322	275	323	302	321	274
		Dusk	277	304	294	302	300	302	295
	8-25	Dawn	220	293	320	283	315	311	315
		Dusk	271	317	291	289	312	313	300
Current Velocity (cm/sec)	8-16	Dawn	41	36	62	57	118	77	0
		Dusk	46	26	98	51	118	77	0
	8-25	Dawn	36	36	51	51	108	77	0
		Dusk	46	31	57	51	118	77	0
Turbidity (NTU)	8-16	Dawn	1.3	1.8	1.8	2.2	1.8	1.5	2.7
		Dusk	1.8	1.7	2.1	1.4	2.2	1.7	1.8
	8-25	Dawn	1.3	1.3	1.6	1.4	1.5	3.8	1.6
		Dusk	0.9	2.1	1.9	1.7	1.7	1.8	1.7

Table 3. Water velocity in cm/sec and depth in meters recorded at 28 benthic and fish netting stations in seven locations between river miles 58 and 66 of the Willamette River, Oregon, June and August 1982.

Sampling period	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel				
	Stoutenberg				Weston Bend				Five Island Bar				Ondland Bar				Five Island Bar				Ondland Bar				Lambert Slough				
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	
June																													
Velocity	41	67	51	67	41	62	67	72	51	67	123	62	93	77	93	72	83	83	57	0	62	46	0	46	0	0	0	0	
Depth	1.8	1.5	2.3	1.8	1.2	2.3	2.3	1.8	1.0	0.9	0.9	0.9	1.5	1.2	1.3	1.3	1.0	0.9	2.0	1.4	1.0	1.0	2.0	0.7	3.0	1.8	1.8	1.5	
August																													
Velocity	26	36	36	46	26	41	31	46	82	93	83	77	46	46	67	77	51	57	41	0	41	46	41	123	0	0	0	0	
Depth	1.8	0.9	1.2	1.5	1.8	1.8	1.2	1.2	0.9	0.6	0.4	0.6	1.8	1.5	1.2	0.9	1.2	0.9	1.8	1.2	0.6	0.6	1.9	0.6	2.4	1.5	1.8	1.5	
AVERAGES																													
June																													
Velocity	57				62				77				82				51	57	41	0	41	46	41	123	0	0	0	0	
Depth	1.9				1.9				0.9				1.3				1.2	0.9	1.3		1.2				2.0				
August																													
Velocity	36				36				83				62				36				62				0				
Depth	1.4				1.5				0.6				1.4				1.3				0.9				1.8				

Abandoned Channel

28. Primary differences in the water quality data occurred between Lambert Slough and the other locations, all of which were more lotic in nature (Tables 1 and 2). Temperatures in Lambert Slough were generally higher than in the main river, ranging from 19.4-23.2° C in August. As expected, temperatures increased from dawn to dusk from the first day of sampling to the last, from June to August, and (in June) from the bottom to the surface. Dissolved oxygen increased between dawn and dusk, and from the bottom to the surface, but readings were higher in June than in August. Values ranged from 15.1 mg/l to a low of 4.0 mg/l recorded on the bottom in June. The latter value was the only indication of dissolved oxygen being a limiting factor in any of the locations. The 15.1 mg/l value was the highest dissolved oxygen level recorded during the study. Excluding these two values, dissolved oxygen levels in Lambert Slough were comparable to those of the other locations. Conductivity levels were much higher in Lambert Slough, ranging from 95 to 132 μ mhos, compared to 69 to 83 μ mhos in the main river. The pH, oxidation-reduction potential, and turbidity readings were similar to those from locations associated with high flow, ranging in value from 6.4-7.4, 220-335 mv, and 1.4-2.7 NTU, respectively.

Fish

Revetments

29. Stoutenberg. A total of 10 species were collected at this location (Figure 8), including 291 individuals weighing a total of 24.4 kg collected with the electroshocker (Figure 9). This was the greatest number of individuals collected from any location. The most common species at Stoutenberg revetment were: northern squawfish (63%), prickly sculpin (12%), largescale sucker (9%), chiselmouth (6%), and redbside shiner (6%) (Table 4).

30. Significantly greater catches using the electroshocker were recorded at Stoutenberg revetment than at other locations for the following species: northern squawfish and chiselmouth during June; prickly sculpin in August; and reticulate sculpin during both sampling periods (Table 5). Stoutenberg also had the greatest catch of chiselmouth by hoopnets in August (Table 6).

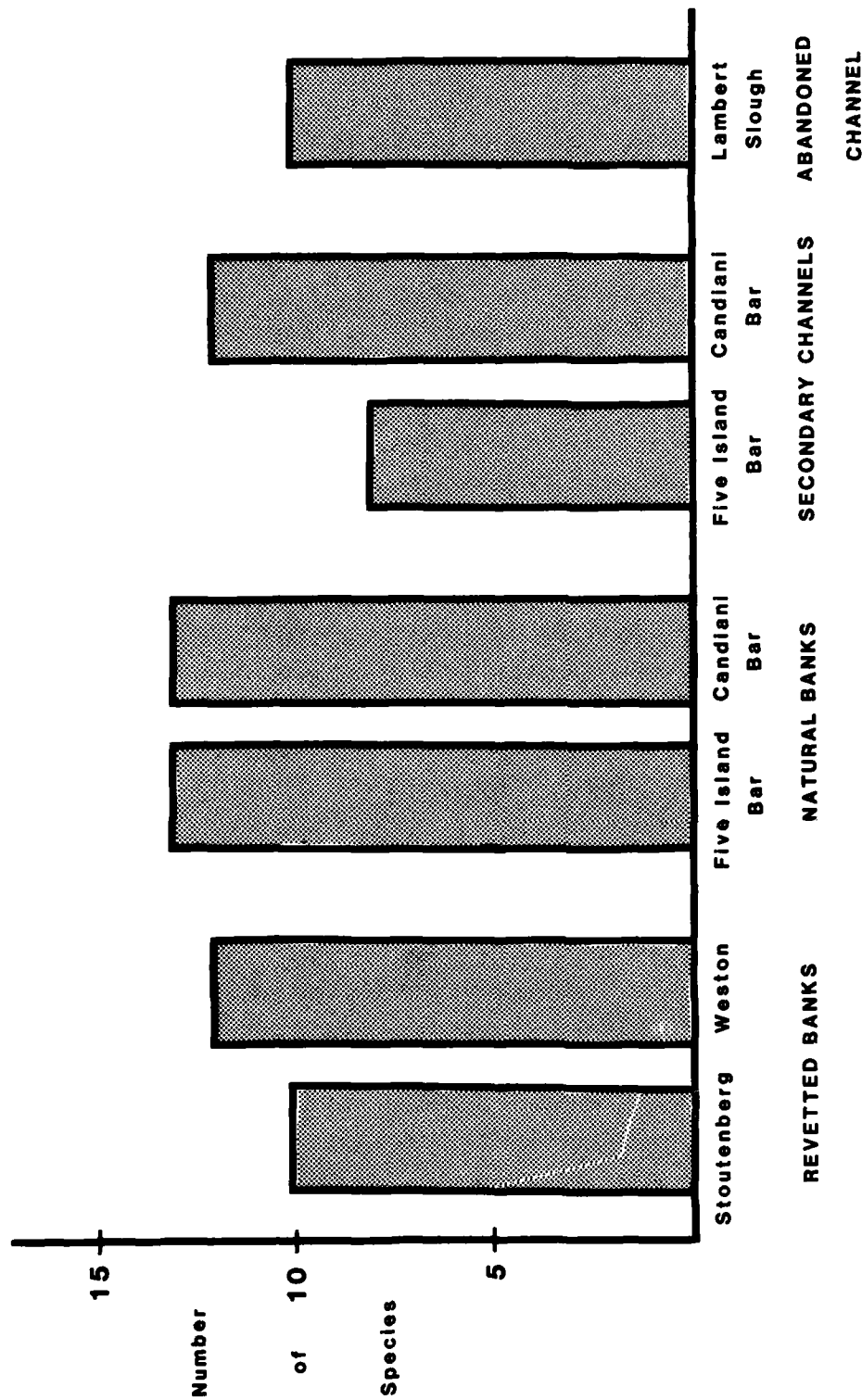


Figure 8. Numbers of species of fish collected by electroshocker and hoopnets from seven locations within four habitat types of the Willamette River during June and August 1982

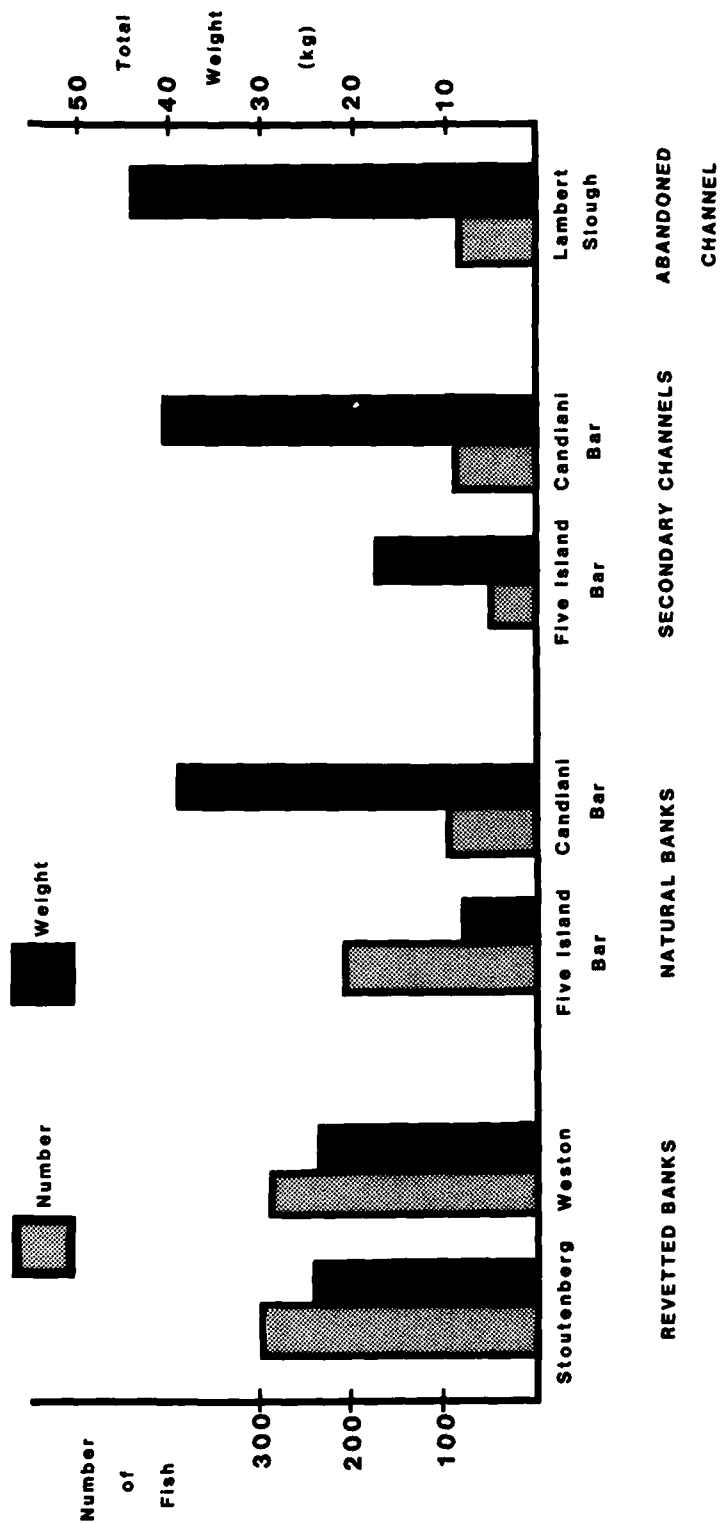


Figure 9. Total numbers and kilograms of fish collected by electroshocking seven locations within four habitat types of the Willamette River during June and August 1982

Table 4. Total species, total individuals, total weight (grams), and dominant species for June and August electroshocker catches, Willamette River, Oregon, 1982. Abbreviated forms of species names are as follows: SQUAW-northern squawfish, PSCULP-prickly sculpin, LSS-large scale sucker, CHIS-chiselmouth, RSS-redside shiner, LEOP-leopard dace, MS-mountain sucker, PEAM-peamouth, LMB-largemouth bass, and WCRAP-white crappie.

	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Total No. Species							
June	8	11	9	7	5	7	8
August	7	7	8	6	4	5	4
Total No. Individuals							
June	150	96	120	39	22	47	54
August	141	174	90	50	27	41	28
Total Weight							
June	17,372	11,725	4,101	20,169	9,052	23,374	29,523
August	7,013	11,948	3,773	18,794	8,427	17,244	14,504
% of Catch of Dominant Species							
Rank							
1	SQUAW 62.9	SQUAW 54.8	LEOP 35.2	LSS 51.7	SQUAW 44.9	LSS 53.4	LSS 61.0
2	PSCULP 11.7	PSCULP 10.9	SQUAW 24.8	SQUAW 33.7	LSS 36.0	SQUAW 21.6	LMB 20.7
3	LSS 8.9	CHIS 9.2	CHIS 11.0	RSS 4.5		PEAM 6.8	WCRAP 4.9
4	CHIS 5.8	RSS 8.9	MS 7.6			CHIS 5.7	SQUAW 6.1
5	RSS 5.8	LSS 8.5	LSS 7.1				

Table 5. Species average catch per transect and results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for the

Willamette River electrofishing catches at seven locations during two sampling periods. Location codes are as follows: ACS, Lambert Slough; NBC, Candiani natural bank; NBF, Five Island natural channel; PCF, Five Island secondary channel; RVN, Weston revetment; and RVT, Stoutenberg revetment. The F values are as follows: 1) Velocity (Vel.) is the covariate of the analysis of covariance; 2) Location (Loc.) is the treatment variable of the analysis of covariance; 3) Adjusted Location (Adj. Loc.) is the location adjusted for the covariate, velocity; and 4) Date is the treatment variable in the complete randomized block analysis of variance where location was the block variable. Significance levels are shown only when they are ≤ 0.05 . Lines underscore the locations which are not significantly different according to Duncan's multiple range test.

Species	Location and Means					F-value Significance					Location and Means					F-value Significance							
	Loc.	ACS	NBC	NBF	PCC	PCF	RVN	RVT	Vel.	Loc.	Adj. Loc.	June	ACS	NBC	NBF	PCC	PCF	RVN	RVT	Vel.	Loc.	Adj. Loc.	Date
Carp	\bar{x}	0.3	0.0	0.0	0.0	0.0	0.0	0.0				ACS	NBC	NBF	PCC	PCF	RVN	RVT					
		0.7	0.0	0.0	0.0	0.0	0.0	0.0				0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.02		
Northern squawfish	RVT	RVN	NBF	PCC	PCF	ACS	NBC					RVN	RVT	NBF	NBC	PCF	PCC	ACS					
	27.7	11.0	4.3	3.3	1.7	1.0	0.7	0.04	0.001	0.0004		38.3	33.3	13.0	9.3	5.7	3.0	0.7		0.0001	0.0001	0.001	0.001
Peamouth	PCC	ACS	PCF	NBC	NBF	RVN	RVT					PCC	RVT	NBC	ACS	NBF	PCF	RVN					
	1.0	0.3	0.3	0.0	0.0	0.0	0.0					1.0	0.7	0.3	0.0	0.0	0.0	0.0		0.03			
Chiselmouth	RVT	RVN	PCC	PCF	NBC	ACS	NBF					NBF	RVN	RVT	NBC	ACS	PCC	PCF					
	4.7	3.0	1.7	1.0	0.3	0.0	0.0	0.05	0.002	0.001		7.7	5.3	1.0	0.7	0.0	0.0	0.0		0.01	0.03		
Largescale sucker	ACS	NBC	PCC	RVT	RVN	PCF	NBF					PCC	ACS	NBC	RVN	NBF	PCF	RVT					
	10.3	9.7	8.7	7.0	4.3	3.7	2.7	0.05				7.0	6.3	5.7	3.3	2.3	2.3	1.7		0.02	0.02		
Mountain sucker	NBF	NBC	ACS	PCC	PCF	RVN	RVT					NBF	PCF	ACS	NBC	PCC	RVN	RVT					
	3.3	0.3	0.0	0.0	0.0	0.0	0.0		0.04			2.0	0.3	0.0	0.0	0.0	0.0	0.0					
Redside shiner	RVN	RVT	NBC	ACS	NBF	PCC	PCF					RVN	RVT	PCC	NBC	ACS	NBF	PCF					
	1.3	1.3	1.0	0.0	0.0	0.0	0.0					6.7	4.3	1.3	0.5	0.0	0.0	0.0		0.0001	0.0001	0.02	
Speckled dace	RVN	NBF	RVT	ACS	NBC	PCC	PCF					RVN	ACS	NBC	NBF	PCC	PCF	RVT					
	2.7	2.0	1.7	0.0	0.0	0.0	0.0		0.004	0.01		1.3	0.0	0.0	0.0	0.0	0.0	0.0		0.02	0.02	0.01	
Leopard dace	NBF	ACS	NBC	PCC	PCF	RVN	RVT					NBF	NBC	ACS	PCC	PCF	RVN	RVT					
	23.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0003	0.001		1.7	0.3	0.0	0.0	0.0	0.0	0.0					

Table 5. (Concluded)

Species	Location and Means							F-value Significance		Location and Means							F-value Significance		
	June							Vel.	Loc.	August							Vel.	Loc.	Adj. Loc.
Mountain whitefish	NBF	ACS	NBC	PCC	PCF	RVN	RVT	NBF	PCC	PCF	ACS	NBC	RVN	RVT					
	1.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	1.3	0.7	0.0	0.0	0.0	0.0					
Chinook salmon	NBC	PCF	RVN	PCC	ACS	NBF	RVT	NBF	ACS	NBC	PCC	PCF	RVN	RVT					
	0.7	0.7	0.7	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0			0.02		
Rainbow trout	RVN	PCC	ACS	NBC	NBF	PCF	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT					
	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Cutthroat trout	NBF	ACS	NBC	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT					
	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
White crappie	ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT					
	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.03		
Smallmouth bass	RVT	ACS	NBC	NBF	PCC	PCF	RVN	ACS	NBC	NBF	PCC	PCF	RVN	RVT					
	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Largemouth bass	ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT					
	4.0	0.3	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0			0.04		
Bluegill	ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT					
	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Channel catfish	ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT					
	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Yellow bullhead	RVN	ACS	NBC	NBF	PCC	PCF	RVT	RVN	ACS	NBC	NBF	PCC	PCF	RVT					
	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0					
Prickly sculpin	RVN	RVT	NBF	PCC	ACS	NBC	PCF	RVT	RVN	ACS	NBC	NBF	PCC	PCF					
	7.0	6.0	0.3	0.3	0.0	0.0	0.0	5.3	2.7	0.0	0.0	0.0	0.0	0.0			0.004		
Torrent sculpin	NBF	ACS	NBC	PCC	PCF	RVN	RVT	NBF	ACS	NBC	PCC	PCF	RVN	RVT					
	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0					
Reticulate sculpin	RVT	RVN	ACS	NBC	NBF	PCC	PCF	RVT	ACS	NBC	NBF	PCC	PCF	RVN					
	1.3	0.7	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0			0.02		
TOTALS (all species pooled)	RVT	NBF	RVN	ACS	PCC	NBC	PCF	RVN	RVT	NBF	NBC	PCC	ACS	PCF					
	50.0	40.0	32.0	18.0	15.7	13.0	7.3	58.0	47.0	30.0	16.7	13.7	9.3	9.0			0.0001 0.0001		

Table 6. Species average catch per 48 hours (two 24-hour sets) and results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for hoopnet catches at seven locations of the Willamette River in June and August, 1982. For an explanation of location codes, F-value significance, and underlined groups see Table 5.

Species	Location and Means										F-value Significance		F-value Significance		
	June					August					Adj.		Vel.	Loc.	Date
	Loc. x	NBC	ACS	NBF	PCC	PCF	RVN	RVT	NBC	ACS	NBF	PCC	PCF	RVN	RVT
Carp		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Northern squawfish		NBC	PCF	RVN	RVT	ACS	NBF	PCC	NBC	RVN	RVT	PCC	ACS	NBF	PCF
		1.0	0.6	0.5	0.3	0.0	0.0	0.0	1.3	1.0	0.8	0.5	0.1	0.1	0.1
Chiselmouth		NBC	RVN	PCF	ACS	NBF	PCC	RVT	RVT	NBC	RVN	NBF	ACS	PCC	PCF
		0.3	0.3	0.1	0.0	0.0	0.0	0.0	1.3	1.1	0.4	0.3	0.0	0.0	0.0
Largescale sucker		NBC	PCF	RVN	NBF	PCC	ACS	RVT	RVN	ACS	NBC	NBF	RVT	PCC	PCF
		1.4	1.0	0.6	0.1	0.1	0.0	0.0	0.6	0.5	0.5	0.3	0.3	0.1	0.0
Black crappie		ACS	PCF	NBC	NBF	PCC	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT
		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0
White crappie		ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT
		0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0
Bluegill		ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	RVN	NBC	NBF	PCC	PCF	RVT
		0.6	0.3	0.3	0.1	0.0	0.0	0.0	1.6	0.1	0.0	0.0	0.0	0.0	0.0
Pumpkinseed		NBF	ACS	NBC	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT
		0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Warmouth		ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT
		0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Yellow bullhead		PCC	ACS	NBC	NBF	PCF	RVN	RVT	RVN	NBC	PCC	ACS	NBF	PCF	RVT
		0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.1	0.1	0.0	0.0	0.0	0.0

Table 7. Average total weight of fish captured, by species, per transect and the results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for the Willamette River electrofishing catches at seven locations during two sampling periods. For an explanation of location codes, F-value significance, and underlined groups see Table 5.

Species	Location and Means										F-value Significance		F-value Significance	
	June										Adj. Loc.		Adj. Loc.	
	Loc.	ACS	NBC	NBF	PCC	PCF	RVN	EVT	Wel.	Loc.	Wel.	Loc.		
Carp	553.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0						
Northern squawfish	2815.7	1450.3	854.0	417.3	241.0	161.3	9.7		0.04	0.0002	0.0001			
Peanouth	PCC	PCF	ACS	NBC	NBF	RVN	EVT							
	239.3	103.3	2.3	0.0	0.0	0.0	0.0							
Chiselmouth	EVT	RVN	PCC	PCF	NBC	ACS	NBF		0.03	0.02				
	633.0	289.3	232.7	90.3	38.3	0.0	0.0							
Largecale sucker	ACS	NBC	PCC	PCF	EVT	RVN	NBF							
	6228.0	5238.7	5158.7	2386.3	2198.0	1890.0	995.7							
Mountain bucker	NBC	NBF	PCC	PCF	RVN	EVT	ACS							
	52.3	31.3	0.0	0.0	0.0	0.0	0.0							
Redside shiner	EVT	RVN	NBC	NBF	PCC	PCF	ACS							
	49.7	30.0	20.3	0.0	0.0	0.0	0.0							
Speckled dace	NBF	RVN	EVT	NBC	PCC	PCF	ACS							
	5.0	4.7	3.3	0.0	0.0	0.0	0.0							
Leopard dace	NBF	ACS	NBC	PCF	PCC	RVN	EVT							
	23.0	0.0	0.0	0.0	0.0	0.0	0.0							
Mountain whitefish	NBF	ACS	NBC	PCF	PCC	RVN	EVT							
	1.3	0.0	0.0	0.0	0.0	0.0	0.0							
Chinook salmon	PCF	RVN	PCC	NBC	ACS	EVT	NBF							
	18.0	8.0	5.0	3.3	0.0	0.0	0.0							
Rainbow trout	RVN	EVT	ACS	PCC	PCF	NBC	NBF		0.02	0.02				
	63.0	0.0	0.0	0.0	0.0	0.0	0.0							

0.0001 0.0001

0.04 0.05 0.05

0.03

Table 7. Concluded.

Species	Location and Means										P-value Significance		
	August										June		
	RVT	NBC	NBC	NBC	NBC	NBC	NBC	NBC	NBC	NBC	W1.	W2.	W3.
Carthrust trout	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Black crappie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White crappie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Shallmouth bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Largemouth bass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bluegill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Channel catfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow perch	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prickly sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Torrent sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Belted sculpin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS (all species pooled)	6264.7	5748.0	4834.7	3982.7	2809.0	2337.7	1257.7						

Table 9. Shannon's diversity index for catches of fish by electroshocking seven Willamette River locations in June and August, 1982.

Location	June 9-11		August 23-25	
	Value	Rank	Value	Rank
Stoutenberg Revetment	0.62	3	0.44	5
Weston Revetment	0.80	1	0.51	3
Five Island Natural Bank	0.66	2	0.69	1
Candiani Natural Bank	0.44	7	0.46	4
Five Island Secondary Channel	0.58	4	0.42	6
Candiani Secondary Channel	0.57	6	0.57	2
Lambert Slough Abandoned Channel	0.57	5	0.41	7

Table 10. Jaccard's similarity index for electroshocker and hoopnet catches of fish from seven Willamette River locations in June and August, 1982.

Locations	June						
	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Stoutenberg Revetment		0.54	0.25	0.31	0.25	0.29	0.12
Weston Bend Revetment			0.22	0.29	0.31	0.54	0.11
Five Island Bar Natural Bank				0.27	0.13	0.25	0.17
Candiani Bar Natural Bank					0.40	0.42	0.29
Five Island Bar Secondary Channel						0.50	0.33
Candiani Bar Secondary Channel							0.27
Average	0.29	0.33	0.22	0.33	0.32	0.38	0.21

Locations	August						
	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Stoutenberg Revetment		0.50	0.25	0.46	0.22	0.44	0.15
Weston Bend Revetment			0.23	0.42	0.20	0.40	0.23
Five Island Bar Natural Bank				0.31	0.50	0.27	0.14
Candiani Bar Natural Bank					0.18	0.50	0.31
Five Island Secondary Channel						0.43	0.20
Candiani Bar Secondary Channel							0.17
Average	0.34	0.33	0.28	0.36	0.29	0.37	0.20

31. The results of the total weights for each species were slightly different from the catch data. Significantly higher total weights for the following species were recorded from Stoutenberg than at any other location: northern squawfish and chiselmouth for June, and reticulate sculpin for both sampling periods (Tables 7 and 8).

32. The diversity of fishes at Stoutenberg was intermediate to that of the other locations. The diversity indices ranked third and fifth among locations for June and August with scores of 0.62 and 0.44, respectively (Table 9). The fishes present at Stoutenberg revetment were most similar to the species at Weston revetment and least similar to the species caught in Lambert Slough for both June and August (Table 10).

33. The only species that was unique to this location was a single smallmouth bass captured in June.

34. Weston. Twelve different species were collected with the electroshocker, including 270 individuals weighing a total of 23.7 kg (Figures 8 and 9). The predominant species were northern squawfish (55%), prickly sculpin (11%), chiselmouth (9%), redbelly shiner (9%), and largescale sucker (8%) (Table 4).

35. Significantly greater catches using the electroshocker were recorded from Weston revetment than the other locations for the following species: rainbow trout and prickly sculpin in June; northern squawfish and redbelly shiner in August; and speckled dace for both sampling periods (Table 5). Hoopnets captured significantly greater numbers of yellow bullheads at Weston than any other location in August (Table 6).

36. The results of the total weights for each species were slightly different from the catch data. Significantly higher total weights were recorded from Weston than any other location for the following species: rainbow trout and prickly sculpin in June; redbelly shiner and speckled dace in August for the electroshocker (Table 7); and yellow bullhead in August for the hoopnets (Table 8).

37. The diversity of fishes at Weston revetment was the highest among locations in June and the third highest in August, with H' values of 0.80 and 0.51, respectively (Table 9). The species present at Weston were most similar to the species at Stoutenberg revetment and Candiani secondary channel in June, and those of Stoutenberg revetment in August. They were least similar to the species at Lambert Slough in June and Five Island secondary channel in August (Table 10).

38. Subadult rainbow trout and banded killifish were unique to Weston revetment.

Natural Banks

39. Five Island. The total weight of fishes captured at Five Island natural bank was the lowest of any of the locations. The electroshocker captured 210 fish weighing a total of 7.9 kg (Figure 9). However, more species of fish were captured at Five Island natural bank and Candiani natural bank (13 each) than at any other location (Figure 8). Major species included leopard dace (35%), northern squawfish (25%), chiselmouth (11%), mountain sucker (8%), and largescale sucker (7%) (Table 4).

40. Significantly greater catches using the electroshocker were recorded from Five Island natural bank for the following species: torrent sculpin, mountain sucker, and leopard dace in June; and chiselmouth in August (Table 5). The diversity of fishes at Five Island natural bank was high compared to the other locations (Table 9). The indices (H') ranked second and first among the locations for June and August, respectively. The species assemblage at Five Island natural bank was dissimilar to those of all other locations except Five Island secondary channel in August. The species were least similar to those present at Five Island secondary channel in June and Lambert Slough in August (Table 10).

41. Species that were unique to Five Island natural bank include torrent sculpin, cutthroat trout, and a single pumpkinseed sunfish. Also, all but one of the leopard dace and all but two of the mountain suckers were captured at Five Island natural bank.

42. Candiani. A total of 13 species were captured at this natural bank site (Figure 8). However, only one individual was collected for each of these four species: largemouth bass, mountain sucker, leopard dace, and yellow bullhead. The electroshocker catch included 89 fish weighing a total of 39.0 kg (Figure 9). Largescale suckers and northern squawfish were the most abundant species at this location, comprising 52% and 34% of the catch, respectively. Redside shiners comprised 5% of the catch (Table 4).

43. Significantly higher numbers of northern squawfish and largescale suckers were caught by hoopnets in June at Candiani natural bank than at any other location (Table 6). Additionally, the total weight of northern

squawfish collected by hoopnets was significantly higher at this location than at any other in August (Table 8).

44. The diversity of fishes at Candiani natural bank was comparatively low, with H' values ranking seventh in June and fourth in August among the seven locations (Table 9). The species composition of Candiani natural bank was most similar to that of Candiani secondary channel for both June and August, and least similar to that of Five Island natural bank in June and Five Island secondary channel in August (Table 10).

45. There were no species that were unique to Candiani natural bank in spite of the large number of species collected there.

Secondary Channels

46. Five Island. Among the seven locations, Five Island secondary channel yielded the lowest total catch (65 fish), the second lowest total weight (17.5 kg), and the lowest number of species (8) (Figures 8 and 9). The most common species were northern squawfish and largescale sucker, comprising 45% and 36% of the catch, respectively (Table 4).

47. The species diversity of Five Island secondary channel was low compared to other locations, with H' values ranking fourth in June and sixth in August (Table 9). The species composition was most similar to that of Candiani secondary channel in June and Five Island natural bank in August (Table 10). The lowest similarity coefficients were obtained with Five Island natural bank in June and Candiani natural bank in August.

48. No unique species were collected at Five Island secondary channel.

49. Candiani. A relatively high number of species (12) (Figure 8) were captured at Candiani secondary channel, while the number of individuals caught (99) was the second lowest among locations (Appendix A). The total catch by electroshocker included 88 fish weighing a total of 40.6 kg (Figure 9). The most abundant species at this location were largescale sucker (53%), northern squawfish (22%), peamouth (7%), and chiselmouth (6%) (Table 4).

50. Two species--peamouth and largescale sucker--were caught in significantly higher numbers by electroshocking Candiani secondary channel than for any other location in June and August (Table 5).

51. The species diversity of this location varied relative to the other locations, with H' values ranking second lowest (0.57) in June and second highest (0.57) in August (Table 9). The species composition was most similar to that of Weston revetment in June and Candiani natural bank in August (Table 10). The lowest similarity values for Candiani secondary channel were found for comparisons with Five Island natural bank in June and Lambert Slough in August.

52. The only species that was unique to Candiani secondary channel was a single brown bullhead captured in June in a hoopnet.

Abandoned Channel

53. Ten species were collected at Lambert Slough by the two gear types (Figure 8). Largescale sucker was the most common species (61% of the catch), followed by largemouth bass (21%), squawfish (6%), and white crappie (5%) (Table 4). The highest total weight of fish caught by electroshocking at any location was recorded from Lambert Slough: 44.0 kg for 82 fish (Figure 9).

54. Largemouth bass was collected in significantly greater numbers by electroshocking Lambert Slough than in any other location during both sampling periods. The same was true of white crappie in June and carp in August (Table 5). More bluegill were caught in hoopnets at Lambert Slough than at any other location during August (Table 6).

55. The total weights of fish collected at Lambert Slough were significantly higher for white crappie electroshocked in June (Table 7) and for bluegill taken by hoopnet in August than at any other location (Table 8).

56. The diversity of fishes at Lambert Slough was relatively low, ranking fifth in June and last in August among seven locations (Table 9). The average of the similarity indices for Lambert Slough was lower than that of all locations for both sampling periods (Table 10).

57. Species that were unique to Lambert Slough included warmouth, channel catfish, and white crappie. In addition, most of the largemouth bass, carp, and bluegill were captured at this location.

Velocity and Sampling Period Effects

58. The abundance of four species--largescale sucker, northern squawfish, black crappie, and chiselmouth--was significantly affected by water velocity (Tables 5-8). Largescale sucker, chiselmouth, and northern squawfish were collected from sites with a wide range of water velocities. Black crappie numbers were correlated with water velocity because four of the five black crappie taken were collected from stations that had no water current.

59. The differences in the catches for June and August were significant for nine species according to the results of the analysis of variance (Tables 5-8). Of fish caught by electroshocking, the numbers of northern squawfish and redbreasted shiner increased from June to August while black crappie, largemouth bass, prickly sculpin, chinook salmon, and speckled dace decreased. Also, the number of chiselmouth captured in the hoopnets increased from June to August, as did the combined weight of electroshocked mountain whitefish.

Species Distribution Patterns

60. Native species (Table 11) were the most abundant and widely distributed throughout the study area. Northern squawfish and largescale suckers were present in all locations during both sampling periods. Chiselmouth were present in all locations except Lambert Slough, and peamouth were absent only at Five Island natural bank and Weston revetment. Only three native species (northern squawfish, peamouth, and largescale sucker) were collected in Lambert Slough. Most of the introduced species (centrarchids, catfishes, and carp) were found primarily in Lambert Slough, excepting yellow bullhead and smallmouth bass.

Table 11. List of fishes collected in the Willamette River (river miles 58-66), Oregon in June and August, 1982. Asterisks denote fishes that are not native to Oregon.

<u>Scientific Name</u>	<u>Common Name</u>
Petromyzontidae	Lampreys
<u>Lampetra (Entosphenus) tridentata</u>	Pacific lamprey
Catostomidae	Suckers
<u>Catostomus macrocheilus</u>	Largescale sucker
<u>Catostomus platyrhynchus</u>	Mountain sucker
Cyprinodontidae	Killifishes
<u>Fundulus Diaphanus</u> *	Banded killifish
Cyprinidae	Minnows, Carps, Daces, Chubs
<u>Cyprinus carpio</u> *	Carp
<u>Ptychocheilus oregonensis</u>	Northern squawfish
<u>Mylocheilus caurinus</u>	Peamouth
<u>Acrocheilus alutaceus</u>	Chiselmouth
<u>Richardsonius balteatus</u>	Redside shiner
<u>Rhinichthys osculus</u>	Speckled dace
<u>Rhinichthys falcatus</u>	Leopard dace
Salmonidae	Salmons, Trouts, Whitefishes
<u>Prosopium williamsoni</u>	Mountain whitefish
<u>Oncorhynchus tshawytscha</u>	Chinook salmon
<u>Salmo gairdneri</u>	Rainbow trout
<u>Salmo clarki</u>	Cutthroat trout
Ictaluridae	Catfishes
<u>Ictalurus punctatus</u> *	Channel catfish
<u>Ictalurus natalis</u> *	Yellow bullhead
<u>Ictalurus nebulosus</u> *	Brown bullhead
Centrarchidae	Sunfishes, Basses
<u>Pomoxis annularis</u> *	White crappie
<u>Pomoxis nigromaculatus</u> *	Black crappie
<u>Lepomis macrochirus</u> *	Bluegill
<u>Lepomis gibbosus</u> *	Pumpkinseed
<u>Lepomis gulosus</u> *	Warmouth
<u>Micropterus dolomieu</u> *	Smallmouth bass
<u>Micropterus salmoides</u> *	Largemouth bass
Cottidae	Sculpins
<u>Cottus asper</u>	Prickly sculpin
<u>Cottus rhotheus</u>	Torrent sculpin
<u>Cottus perplexus</u>	Reticulate sculpin

Benthic Invertebrates

Revetments

61. Stoutenberg. Stoutenberg revetment supported the greatest number of benthic invertebrates when totals for both sampling periods were combined (Figure 10). In June, this location supported the greatest number of taxa (57) (Figure 11). The most common taxa in June were Anisogammarus (36%), Paratanytarsus (12%), Oligochaeta (10%), and Manayunkia (10%) (Table 12). The taxa composition in August reflected a decrease in the proportion of Anisogammarus to 19%, concomitant with an increase in the proportion in the other predominant taxa: Oligochaeta (21%), Manayunkia (20%), and Orthocladus-Cricotopus (13%) (Table 13).

62. Many taxa were found in significantly higher densities at Stoutenberg revetment than at any other location. Those taxa were: Anisogammarus, Pacifastacus, Paratanytarsus, Orthocladus-Cricotopus, and Nanocladus for both sampling periods; Nematomorpha, Paraleptophlebia, Serratella, Tricorythodes, Hydropsyche, Cheumatopsyche, Hydroptila, Psychomyia, Rheocricotopus, Potthastia, and Xenochironomus in June; and Oligochaeta, Manayunkia, Centroptilum, Ceraclea, Endochironomus, Dicrotendipes, and Ferrissia in August (Table 14).

63. The following taxa were widespread (present in at least five other locations) but were least abundant at Stoutenberg: Fluminicola during June and Tricoptera pupae, Procladius, and Corbicula during August (Table 14).

64. The diversity of invertebrates at Stoutenberg revetment was intermediate to that of the other locations, with H' values ranking second (1.04) in June and sixth (1.01) in August (Table 15). The taxa collected at Stoutenberg were most similar to those at Weston revetment and least similar to those at Lambert Slough in both June and August (Table 16).

65. The taxa collected only at Stoutenberg were Zapada, Polycentropus, Aturus, and Xenochironomus.

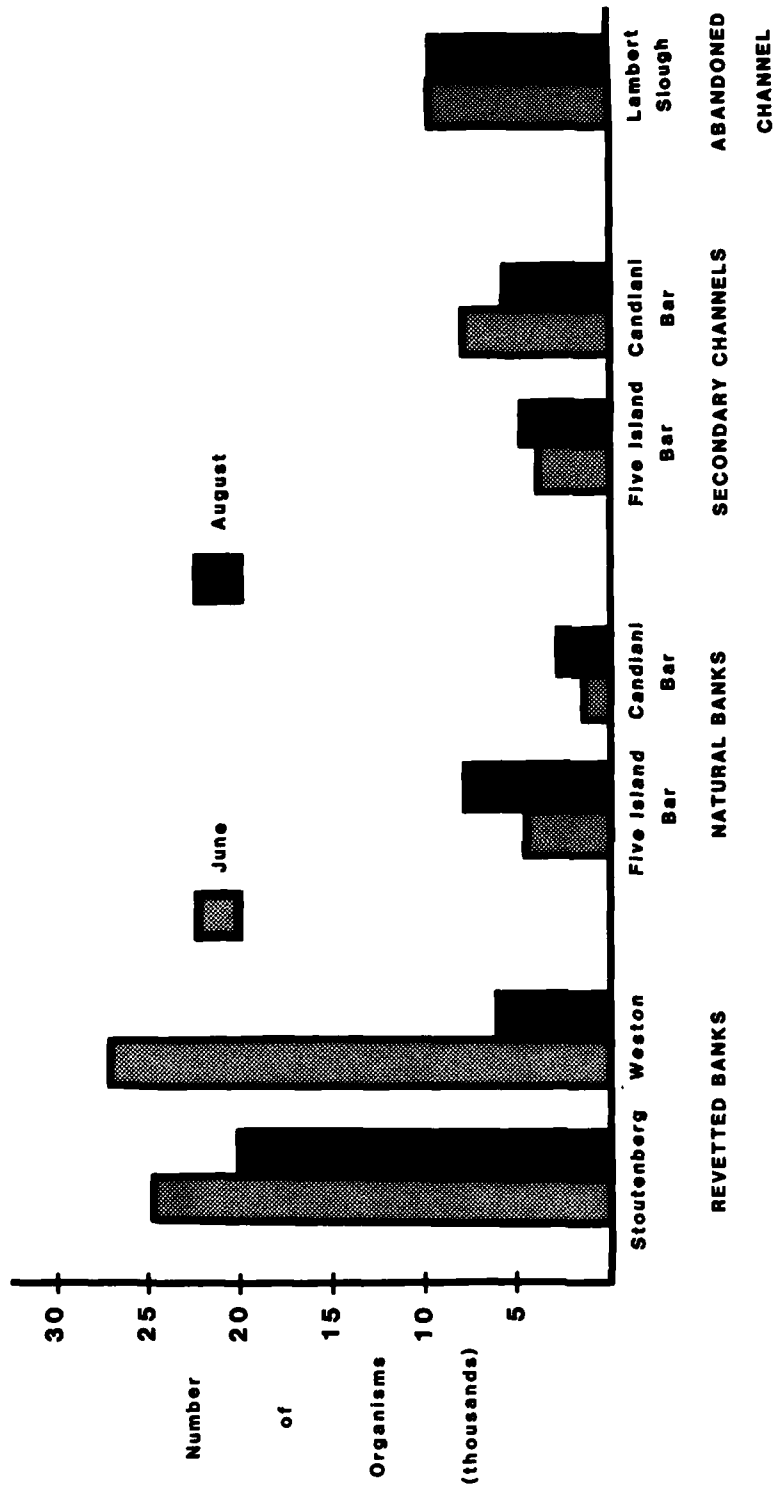


Figure 10. Total number of benthic invertebrates, by sampling period, collected from seven locations within four habitat types of the Willamette River during June and August 1982

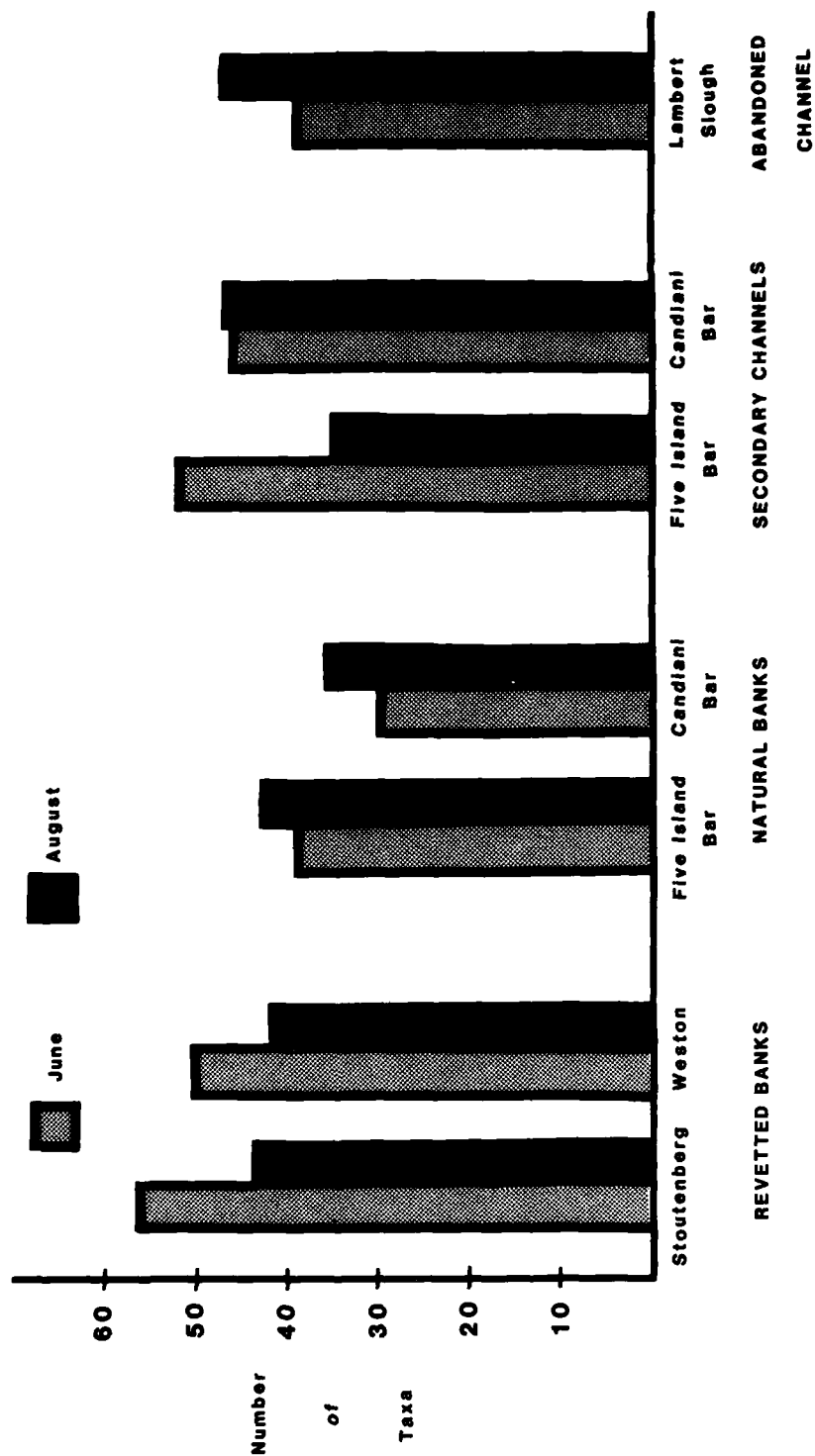


Figure 11. Number of taxa of benthic invertebrates, by sampling period, collected from seven locations within four habitat types of the Willamette River during June and August 1982

Table 12. Percent occurrence by location of the six most abundant taxa of benthic invertebrates collected from river mile 58-66 of the Willamette River, Oregon, in June, 1982.

Revetted Banks				Natural Banks				Secondary Channels				Abandoned Channel	
Stoutenberg		Weston Bend		Five Island Bar		Candiani Bar		Five Island Bar		Candiani Bar		Lambert Slough	
Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%
<u>Anisogammarus</u>	36	<u>Anisogammarus</u>	31	<u>Orthocladius-Cricotopus</u>	36	<u>Oligochaeta</u>	22	<u>Oligochaeta</u>	33	<u>Endochironomus</u>	30	<u>Oligochaeta</u>	60
<u>Paratanytarsus</u>	12	<u>Manayunkia</u>	20	<u>Paratanytarsus</u>	11	<u>Orthocladius-Cricotopus</u>	20	<u>Chironomus</u>	15	<u>Oligochaeta</u>	21	<u>Procladius</u>	12
<u>Oligochaeta</u>	10	<u>Oligochaeta</u>	18	<u>Rheotanytarsus</u>	9	<u>Paratanytarsus</u>	19	<u>Endochironomus</u>	10	<u>Chironomus</u>	9	<u>Dubiraphia</u> larvae	5
<u>Manayunkia</u>	10	<u>Orthocladius-Cricotopus</u>	5	<u>Oligochaeta</u>	9	<u>Rheotanytarsus</u>	13	<u>Juga</u>	8	<u>Juga</u>	9	<u>Helobdella</u>	5
<u>Orthocladius-Cricotopus</u>	9	<u>Paratanytarsus</u>	5	<u>Chironomidae</u> pupae	8	<u>Chironomidae</u> pupae	5	<u>Fluminicola</u>	6	<u>Fluminicola</u>	7	<u>Asellus</u>	3
<u>Rheotanytarsus</u>	4	<u>Microtendipes</u>	4	<u>Polypedilum</u>	6	<u>Nematomorpha</u>	4	<u>Corbicula</u>	3	<u>Orthocladius-Cricotopus</u>	3	<u>Tanytarsus</u>	3
Total	81	Total	83	Total	79	Total	83	Total	74	Total	79	Total	88

Table 13. Percent occurrence by location of the six most abundant taxa of benthic invertebrates collected from river miles 58-66 of the Willamette River, Oregon, in August, 1982.

Revetted Banks				Natural Banks				Secondary Channels				Abandoned Channel	
Stoutenberg		Weston Bend		Five Island Bar		Candiani Bar		Five Island Bar		Candiani Bar		Lambert Slough	
Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%	Taxa	%
<u>Oligochaeta</u>	21	<u>Manayunkia</u>	29	<u>Fluminicola</u>	20	<u>Nematomorpha</u>	21	<u>Fluminicola</u>	42	<u>Fluminicola</u>	33	<u>Procladius</u>	26
<u>Manayunkia</u>	20	<u>Anisogammarus</u>	15	<u>Orthocladius-Cricotopus</u>	17	<u>Orthocladius-Cricotopus</u>	20	<u>Sphaeriidae</u>	18	<u>Juga</u>	25	<u>Oligochaeta</u>	22
<u>Anisogammarus</u>	19	<u>Ceracea</u>	13	<u>Rheotanytarsus</u>	11	<u>Polypedilum</u>	15	<u>Juga</u>	17	<u>Sphaeriidae</u>	23	<u>Cladopelma</u>	9
<u>Orthocladius-Cricotopus</u>	13	<u>Orthocladius-Cricotopus</u>	10	<u>Eukiefferiella</u>	11	<u>Anisogammarus</u>	9	<u>Oligochaeta</u>	9	<u>Oligochaeta</u>	5	<u>Aesellus</u>	8
<u>Ceracea</u>	7	<u>Oligochaeta</u>	10	<u>Polypedilum</u>	8	<u>Stenonema</u>	9	<u>Nematomorpha</u>	2	<u>Tricorythodes</u>	4	<u>Dubiraphia larvae</u>	8
<u>Polypedilum</u>	3	<u>Polypedilum</u>	3	<u>Synorthocladius</u>	4	<u>Sphaeriidae</u>	4	<u>Paracladopelma</u>	2	<u>Nematomorpha</u>	4	<u>Chironomus</u>	3
Total	84	Total	80	Total	71	Total	78	Total	90	Total	94	Total	76

Table 14. Average invertebrate abundance by taxa and results of the analysis of variance, analysis of covariance, and Duncan's multiple range tests for invertebrate samples collected at seven locations of the Willamette River in June and August, 1982. For an explanation of location codes, P-value significance, and underlined groups see Table 5.

PHYLUM CLASS ORDER Family Genus, Species	Locations and Means										P-value Significance		
	June					August					Adj.		
	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
HEMPTODA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	12.0	8.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEMATOPHYA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	63.3	40.3	37.3	21.5	15.8	14.3	9.5	0.02	0.03	0.01	0.0002	0.001	0.0002
ANNELIDA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	1485.0	1193.3	620.3	430.8	330.5	101.3	86.3	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
OLIGOCHAETA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	53.8	25.5	1.0	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BRANCHIOBELLIDA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	1321.8	601.5	18.0	11.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POLYCHAETA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HIRUDINIA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	116.8	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Glossiphoniidae	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	116.8	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ARTHEMPODA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRUSTACEA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	69.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ISOPODA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	2224.5	2072.3	27.0	14.0	6.5	2.8	0.0	0.001	0.001	0.001	0.0001	0.0001	0.0001
AMPHIPODA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	12.5	11.3	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Talitridae	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	21.0	13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DECAPODA	Loc.	ACS	RVT	PCF	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT	WVT
	21.0	13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(Continued)

(Sheet 1 of 7)

Table 14. Continued

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Table 14. Continued

PHTLUM CLASS	ORDER	Family	Genus, Species	Locations and Means										P-value Significance		Locations and Means										P-value Significance								
				June					August					Vel.		June					August					Vel.								
				RVT	RVN	PCF	NBF	ACS	RVT	RVN	PCF	NBF	ACS	RVT	RVN	PCF	NBF	ACS	RVT	RVN	PCF	NBF	ACS	RVT	RVN	PCF	NBF	ACS	RVT	RVN	PCF	NBF	ACS	
Tricorythidae	Tricorythodes			RVT	21.0	11.3	7.0	3.5	3.3	3.0	0.0	0.03			NBF	53.5	32.3	14.5	7.3	5.0	1.0	0.0												
			ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCF	RVN	RVT	ACS	NBC	NBF	PCF	RVN	RVT	ACS	NBC	NBF	PCF	RVN	RVT	ACS	NBC	NBF	PCF	RVN	RVT	
Cassidae	Cassia			7.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0				15.8	0.0	0.0	0.0	0.0	0.0	0.0													
																																		0.05
Ephemerellidae	Ephemerella			RVT	17.0	9.3	3.5	1.3	1.0	0.5	0.0					PCC	0.3	0.0	0.0	0.0	0.0	0.0												
																																		0.0001
Hemipteridae	Rithogenus			NBF	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.02				PCC	4.3	2.5	0.0	0.0	0.0	0.0												
																																		0.001
Stenonema	Stenonema			RVT	21.0	16.3	5.0	1.8	0.5	0.0	0.0	0.002				NBC	55.5	14.0	11.5	11.3	11.0	3.8	0.0											
Hemipteridae	Hemipteridae			RVT	9.0	5.8	3.5	2.8	0.5	0.0	0.0					RVT	3.0	1.5	0.5	0.0	0.0	0.0												
Bettidae	Goniostellum			RVT	27.0	15.8	3.0	0.8	0.0	0.0	0.0					RVT	24.8	2.0	1.3	0.0	0.0	0.0												
Bettidae	Bettidae			RVT	3.5	1.0	0.0	0.0	0.0	0.0	0.0					ACS	0.0	0.0	0.0	0.0	0.0	0.0												
																																		0.01
Pseudocloeon	Pseudocloeon			RVT	12.0	10.8	5.0	4.0	3.5	1.0	0.0					NBF	35.8	4.3	0.5	0.5	0.0	0.0												
Odonata	Coenagrionidae			ASC	0.0	0.0	0.0	0.0	0.0	0.0	0.0					ACS	0.0	0.0	0.0	0.0	0.0	0.0												
MEGALOPTERA	Stalidae			ACS	16.8	0.0	0.0	0.0	0.0	0.0	0.0					ASC	0.0	0.0	0.0	0.0	0.0	0.0												
HEMIPTERA	Styriidae			ACS	6.0	2.3	0.0	0.0	0.0	0.0	0.0					NBC	0.3	0.0	0.0	0.0	0.0	0.0												
Tetraneura	(pupae)			RVT	34.8	29.3	3.8	2.8	2.3	0.8	0.0	0.01				PCF	2.5	0.0	0.0	0.0	0.0	0.0												
Hydroptilidae	Hydroptilidae			RVT	34.0	20.0	2.3	0.6	0.3	0.0	0.0	0.003				PCF	28.5	8.5	4.3	1.3	0.0	0.0												
																																		0.002

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(Sheet 3 of 7)

(Continued)

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(Sheet 3 of 7)

Table 14. Continued

PHYLUM CLASS ORDER Family Genus, Species	Locations and Means										F-value Significance		
	June					August					Adj.		
	WV	PCF	MBF	ACS	NBC	WV	PCF	MBF	ACS	NBC	WV	PCF	NBC
<u>Chamaeleonidae</u>													
	93.3	43.5	1.8	1.5	0.0	20.8	15.5	14.3	6.5	5.8	0.0004	0.0004	0.0004
<u>Hydrophilidae</u>													
	0.3	0.0	0.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005
<u>Hydrophilidae</u>													
	16.8	13.0	0.0	0.0	0.0	10.8	10.3	6.0	0.5	0.0	0.0005	0.0005	0.0005
<u>Leptoceridae</u>													
	6.0	0.0	0.0	0.0	0.0	31.8	0.0	0.0	0.0	0.0	0.0005	0.0005	0.0005
<u>Cetonia</u>													
	2.0	1.5	0.5	0.0	0.0	34.5	20.0	14.8	13.5	8.0	0.0005	0.0005	0.0005
<u>Glossomatidae</u>													
	8.8	5.0	0.8	0.0	0.0	34.8	19.0	15.8	0.0	0.0	0.0005	0.0005	0.0005
<u>Proctophila</u>													
	6.3	0.3	0.0	0.0	0.0	7.8	2.0	0.0	0.0	0.0	0.0005	0.0005	0.0005
<u>Psychomyidae</u>													
	10.8	0.0	0.0	0.0	0.0	39.0	21.5	5.3	0.0	0.0	0.0005	0.0005	0.0005
<u>Pyralidae</u>													
	42.8	9.5	0.3	0.0	0.0	134.0	47.5	20.5	0.0	0.0	0.0001	0.0001	0.0001
<u>Pyralidae</u>													
	116.3	21.0	2.3	1.0	0.0	180.8	1.3	0.0	0.0	0.0	0.0002	0.0002	0.0002
<u>Pyralidae</u>													
	9.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0	0.0002	0.0002	0.0002
<u>Pyralidae</u>													
	0.5	0.5	0.3	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0002	0.0002	0.0002
<u>Pyralidae</u>													
	2.3	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0002	0.0002	0.0002
<u>Pyralidae</u>													
	2.0	0.0	0.0	0.0	0.0	13.5	5.8	3.0	0.3	0.0	0.0002	0.0002	0.0002
<u>Pyralidae</u>													
	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0002	0.0002	0.0002

(Continued)

(Sheet 4 of 7)

Table 14. Continued

FNLIN CLASS ORDER	Family Genus, Species	Locations and Means										F-value Significance			F-value Significance		
		June					August					Adj. Loc.	Wei.	Loc.	Adj. Loc.	Wei.	Loc.
		ACS	NBC	NBP	PCC	PCF	RVT	ACS	NBC	NBP	PCF	RVT					
Simuliidae	(pupae)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		0.8	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Simuliidae	(larvae)	0.8	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		0.8	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Empididae	Nematodromia (larvae)	4.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		4.3	3.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Empididae	(pupae)	4.3	3.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		4.3	3.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Ephyrididae	(larvae)	7.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		7.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Ceratopogonidae	Basia-Prothessia	26.5	2.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		26.5	2.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Palpomyia	(pupae)	9.0	8.8	3.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		9.0	8.8	3.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Chironomidae	(pupae)	245.3	170.8	99.3	21.0	18.3	1.8	0.0	0.0	0.0	0.0	0.0					
		245.3	170.8	99.3	21.0	18.3	1.8	0.0	0.0	0.0	0.0	0.0					
Rheotanytarsus	(pupae)	265.5	257.3	105.8	51.8	25.3	7.8	0.0	0.0	0.0	0.0	0.0					
		265.5	257.3	105.8	51.8	25.3	7.8	0.0	0.0	0.0	0.0	0.0					
Cricotopus	(pupae)	19.5	10.8	9.5	6.3	2.8	0.3	0.0	0.0	0.0	0.0	0.0					
		19.5	10.8	9.5	6.3	2.8	0.3	0.0	0.0	0.0	0.0	0.0					
Eubiefferiella	(pupae)	44.5	10.5	9.0	6.8	6.5	3.8	1.8	0.0	0.0	0.0	0.0					
		44.5	10.5	9.0	6.8	6.5	3.8	1.8	0.0	0.0	0.0	0.0					
Synorthocladus	(pupae)	23.8	8.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
		23.8	8.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
Paracanytarus	(pupae)	765.0	365.5	103.8	75.3	16.8	4.5	4.3	0.0	0.0	0.0	0.0					
		765.0	365.5	103.8	75.3	16.8	4.5	4.3	0.0	0.0	0.0	0.0					
Orthocladus-Cricotopus	(pupae)	539.3	421.5	369.5	75.8	58.5	14.5	0.0	0.0	0.0	0.0	0.0					
		539.3	421.5	369.5	75.8	58.5	14.5	0.0	0.0	0.0	0.0	0.0					
Endochironomus	(pupae)	618.3	104.5	75.8	27.5	22.0	16.5	2.3	0.0	0.0	0.0	0.0					
		618.3	104.5	75.8	27.5	22.0	16.5	2.3	0.0	0.0	0.0	0.0					
Dicrotendipes	(pupae)	264.3	165.0	31.3	26.5	11.3	3.3	1.3	0.0	0.0	0.0	0.0					
		264.3	165.0	31.3	26.5	11.3	3.3	1.3	0.0	0.0	0.0	0.0					

(Sheet 5 of 7)

Table 14. Continued

PHYTUM CLASS ORDER Family Genus, Species	Locations and Means										F-value Significance		
	June					August					Vel.		
	RVT	PCC	RVN	ACS	NBC	NBF	PCF	RVT	PCC	RVN	ACS	NBC	NBF
<u>Rhynchospora</u>	24.0	19.5	5.3	0.0	0.0	0.0	0.0	48.8	20.3	6.0	0.0	0.0	0.0
<u>Manisuris</u>	57.5	53.8	6.3	0.0	0.0	0.0	0.0	45.2	50.0	0.0	0.0	0.0	0.0
<u>Stenochironomus</u>	5.5	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
<u>Tanaisia</u>	71.0	64.0	43.8	27.0	22.5	16.0	10.3	48.8	20.3	6.0	0.0	0.0	0.0
<u>Brillia</u>	14.5	7.3	0.8	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>Polypodium</u>	74.6	41.0	24.5	21.5	18.0	13.5	4.5	159.3	141.3	97.0	50.0	20.0	15.3
<u>Chironomus</u>	179.8	148.0	48.3	9.3	0.3	0.0	0.0	85.8	9.5	8.5	6.3	2.0	1.0
<u>Thienmanniella</u>	30.8	2.8	1.3	0.8	0.3	0.0	0.0	4.8	4.3	2.0	0.0	0.0	0.0
<u>Stenopeltis</u>	19.5	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<u>Procladius</u>	287.5	19.0	9.0	0.3	0.0	0.0	0.0	620.0	8.5	3.0	0.5	0.0	0.0
<u>Microgaster</u>	9.3	3.3	0.3	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0
<u>Paraclopedes</u>	19.0	1.5	0.5	0.0	0.0	0.0	0.0	20.3	6.0	5.3	3.8	0.0	0.0
<u>Cryptochironomus</u>	19.0	0.3	0.0	0.0	0.0	0.0	0.0	27.8	15.8	12.5	6.3	4.3	0.5
<u>Pothosia</u>	29.5	9.5	6.8	4.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0
<u>Cladophora</u>	27.3	0.0	0.0	0.0	0.0	0.0	0.0	224.8	0.0	0.0	0.0	0.0	0.0

(Continued)

(Sheet 6 of 7)

Table 14. Concluded

PHYLUM CLASS ORDER Family Genus, Species	Locations and Means										F-value Significance			F-value Significance				
	June										August			Val.				
	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT	ACS	NBC	NBF	PCC	PCF	RVN	RVT	Adj.	Loc.	Date
<u>Abalabaria</u>	8.0	4.5	0.0	0.0	0.0	0.0	0.0		6.0	0.0	0.0	0.0	0.0	0.0	0.0			
<u>Parachironomus</u>	RVT	ACS	NBC	NBF	PCC <td>PCF</td> <td>RVN</td> <td></td> <td>ACS</td> <td>RVT</td> <td>RVN</td> <td>NBC</td> <td>NBF</td> <td>PCC</td> <td>PCF</td> <td></td> <td></td> <td></td>	PCF	RVN		ACS	RVT	RVN	NBC	NBF	PCC	PCF			
	10.8	6.8	0.0	0.0	0.0	0.0	0.0		19.3	8.8	0.5	0.0	0.0	0.0	0.0			
<u>Dialabastera</u>	ACS	RVT	NBC	NBF	PCC	PCF	RVN		ACS	NBC	NBF	PCC	PCF	RVN	RVT			
	4.8	0.3	0.0	0.0	0.0	0.0	0.0		0.3	0.0	0.0	0.0	0.0	0.0	0.0			
<u>Xenochironomus</u>	RVT	ACS	NBC	NBF	PCC	PCF	RVN	0.04	0.04									
	18.8	0.0	0.0	0.0	0.0	0.0	0.0		18.3	0.0	0.0	0.0	0.0	0.0	0.0			
<u>Paralautebornella</u>	ACS	NBC	NBF	PCC	PCF	RVN	RVT		PCF	ACS	NBC	NBF	PCC	RVN	RVT			
	0.0	0.0	0.0	0.0	0.0	0.0	0.0		2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.02	0.01	
MOLLUSCA																		
CASTROPODA																		
<u>Jura</u>	PCC	PCF	ACS	NBC	NBF	RVN	RVT	0.01	0.01									
	178.0	83.3	0.0	0.0	0.0	0.0	0.0		361.0	201.0	18.8	17.0	11.3	2.0	0.0			
<u>Hydrobiidae</u>	PCC	PCF	NBF	RVN	ACS	NBC	RVT	0.001	0.002									
<u>Fluminicola</u>	153.8	61.3	23.8	0.5	0.3	0.0	0.0		498.0	480.0	397.3	8.0	4.3	3.3	1.8			0.01
<u>Ancylidae</u>	PCF	RVN	RVT	ACS	NBC	NBF	PCC	0.03	0.02									
<u>Partigala</u>	6.0	2.0	2.0	0.0	0.0	0.0	0.0		43.5	5.3	1.0	0.0	0.0	0.0	0.0			
<u>Planorbidae</u>	PCF	ACS	NBC	NBF	PCC	RVN	RVT		PCF	PCC	ACS	NBC	NBF	RVN	RVT			
<u>Vorticifex (Parapholyx)</u>	0.5	0.0	0.0	0.0	0.0	0.0	0.0		3.5	1.8	0.0	0.0	0.0	0.0	0.0	0.001	0.001	
PELECYPODA																		
<u>Margaritiferidae</u>	ACS	PCF	NBC	NBF	PCC	RVN	RVT		ACS	PCF	NBC	NBF	PCC	RVN	RVT			
<u>Margaritifera</u>	0.3	0.3	0.0	0.0	0.0	0.0	0.0		0.3	0.3	0.0	0.0	0.0	0.0	0.0			
<u>Corbiculidae</u>	PCF	PCC	RVN	ACS	NBC	NBF	RVT	0.01	0.003	0.001								
<u>Corbicula</u>	31.0	4.8	1.8	0.0	0.0	0.0	0.0		8.5	2.3	1.8	0.5	0.3	0.3	0.0	0.02	0.01	
<u>Sphaeriidae</u>	PCF	RVN	PCC	RVT	ACS	NBC	NBF		PCF	PCC	ACS	NBC	RVT	RVN	NBF			
	19.5	15.5	14.5	3.3	0.0	0.0	0.0		220.8	125.5	60.8	22.3	6.0	3.0	1.0	0.01		
TOTALS (all taxa pooled)	RVN	RVT	ACS	PCC	NBF	PCF	NBC	0.001	0.001									
	6764.3	6219.0	2398.8	2100.5	1176.3	1023.3	367.5		5052.3	2355.3	1949.8	1561.5	1470.5	1196.0	626.3	0.02	0.03	
(Sheet 7 of 7)																		

(Sheet 7 of 7)

Table 15. Shannon's diversity index for benthic invertebrates
collected from seven Willamette River locations in June and
August, 1982.

Location	June		August	
	Value	Rank	Value	Rank
Stoutenberg Revetment	1.04	2	1.01	6
Weston Revetment	0.96	6	1.05	4
Five Island Natural Bank	0.97	5	1.15	1
Candiani Natural Bank	0.97	4	1.08	3
Five Island Secondary Channel	1.11	1	0.84	7
Candiani Secondary Channel	1.04	3	1.03	5
Lambert Slough Abandoned Channel	0.73	7	1.11	2

Table 16. Jaccard's similarity index for benthic invertebrates collected from seven Willamette River locations in June and August, 1982.

Locations	June						Abandoned Channel
	Revetted Banks		Natural Banks		Secondary Channels		
	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	
Stoutenberg Revetment		0.61	0.39	0.42	0.43	0.41	0.25
Weston Bend Revetment			0.46	0.40	0.50	0.48	0.21
Five Island Bar Natural Bank				0.53	0.49	0.57	0.15
Candiani Bar Natural Bank					0.38	0.41	0.17
Five Island Bar Secondary Channel						0.64	0.21
Candiani Bar Secondary Channel							0.19
Average	0.42	0.44	0.43	0.39	0.44	0.45	0.20

Locations	August						Abandoned Channel
	Revetted Banks		Natural Banks		Secondary Channels		
	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	
Stoutenberg Revetment		0.65	0.49	0.42	0.38	0.48	0.24
Weston Bend Revetment			0.53	0.44	0.45	0.49	0.27
Five Island Bar Natural Bank				0.47	0.48	0.55	0.22
Candiani Bar Natural Bank					0.43	0.46	0.18
Five Island Secondary Channel						0.51	0.27
Candiani Bar Secondary Channel							0.32
Average	0.43	0.47	0.46	0.40	0.42	0.47	0.25

66. Weston. Weston revetment supported the greatest number of invertebrates for a sampling period, with 27,128 organisms representing 51 taxa collected in June (Figures 10 and 11). In August, however, Weston ranked fourth in number of invertebrates, with 6,288 representing 42 taxa (Figures 10 and 11). The patterns of taxa composition were similar to that of Stoutenberg, with Anisogammarus decreasing from 31% of the total in June to 14% in August (Tables 12 and 13). Other abundant taxa were Manayunkia (20%) and Oligochaeta (18%) in June (Table 12), and Manayunkia (28%), Ceraclea (13%), Orthocladius-Cricotopus (10%), and Oligochaeta (10%) in August (Table 13).

67. Six taxa were collected in significantly higher densities at Weston than at any other location in June: Manayunkia, Stenonema, Hemerodromia, Rheotanytarsus, Dicrotendipes, and Chironomidae pupae (Table 14). None, however, was at significantly higher densities at Weston than at the other locations in August.

68. The following taxa were widespread (present in at least five locations) but were least abundant or absent at Weston revetment: Thienemanniella during June, and Palpomyia, Cryptochironomus, and Fluminicola during August (Table 14).

69. The diversity of invertebrates at Weston revetment was comparatively low, ranking sixth in June ($H' = 0.96$) and fourth in August ($H' = 1.05$) among the seven locations (Table 15). The invertebrate taxa composition of Weston was most like that of Stoutenberg and least like that of Lambert Slough during both sampling periods (Table 16).

70. The only taxa found exclusively at Weston revetment were three genera of Chironomidae: Symposiocladius, Stictochironomus, and Stenochironomus.

Natural Banks

71. Five Island. The benthic invertebrates at Five Island natural bank were notably less abundant in June than in August. Only 4,712 individuals in 39 taxa were taken in June, while 7,949 in 43 taxa were collected in August (Figures 10 and 11). The most numerous taxa were Orthocladius-Cricotopus (17%), Paratanytarsus (11%), Rheotanytarsus (9%), and Oligochaeta (9%) in June (Table 12), and Fluminicola (20%), Orthocladius-Cricotopus (17%), Rheotanytarsus (11%), and Eukiefferiella (11%) in August (Table 13).

72. Palpomyia were significantly more abundant in June at Five Island natural bank than at any other location, as were Cricotopus in August (Table 14).

73. The following taxa were widespread (present in at least five locations) but were absent or least abundant at Five Island natural bank: Manayunkia during both sampling periods, Brillia and Chironomus during June, and Procladius and Sphaeriidae during August (Table 14).

74. The diversity of invertebrates at Five Island natural bank increased from fifth highest ($H' = 0.97$) in June to the highest ($H' = 1.15$) of any location in August (Table 15). The invertebrate taxa composition was most similar to that of Candiani secondary channel and least similar to that of Lambert Slough during both sampling periods (Table 16).

75. Three genera--Anystis, Dicosmoecus, and Placobdella--were found only at Five Island natural bank.

76. Candiani. Candiani natural bank supported the lowest densities of invertebrates (1,547 in June, 2,538 in August) and the fewest taxa (30 in June) of any location (Figures 10 and 11). The most abundant taxa in June were Oligochaeta (22%), Orthocladius-Cricotopus (20%), Paratanytarsus (19%), and Rheotanytarsus (14%) (Table 12), while Nematomorpha (21%), Orthocladius-Cricotopus (20%), Polypedilum (15%), and Stenonema (9%) were most numerous in August (Table 13).

77. Numerous widespread taxa were either absent or least abundant at this location. These were: Oligochaeta, Tanytarsus, and Chironomus during both sampling periods; Branchiobdellida, Heptagenia, Hydropsyche, Cheumatopsyche, Eukiefferiella, Endochironomus, Dicrotendipes, Brillia, Polypedilum, and Fluminicola during June; and Synorthocladius and Tricoptera pupae during August (Table 14).

78. The diversity of invertebrates at Candiani natural bank was intermediate with respect to the other locations, ranking fourth ($H' = 0.97$) in June and third ($H' = 1.08$) in August (Table 15). The taxa collected at Candiani natural bank were most similar to those at Five Island natural bank, and were least similar to those of Lambert Slough in both June and August (Table 16).

79. Taxa that were found only at Candiani natural bank are Claassenia, Brachycentrus, and Pentaneura.

Secondary Channels

80. Five Island. Five Island secondary channel supported the second lowest densities of invertebrates in June (4,075) and in August (4,916), as well as the fewest taxa (35) for August (Figures 10 and 11). The taxa of greatest abundance in June were Oligochaeta (32%), Chironomus (15%), Endochironomus (10%), Juga (8%), and Fluminicola (6%) (Table 12). The proportions were very different in August, however, with Fluminicola (42%), Sphaeriidae (18%), Juga (17%), and Oligochaeta (9%) being the predominant taxa (Table 13).

81. Four taxa were found in significantly higher densities at Five Island secondary channel than at any other location: Corbicula during both sampling periods, Protophila and Ferrissia in June, and Paralauterborniella in August (Table 14).

82. The following widespread (present in at least five locations) taxa were least abundant or absent at Five Island secondary channel: Chironomidae pupae during both sampling periods; Lebertia, Endochironomus, and Dicrotendipes in June; and Anisogammarus in August (Table 14).

83. The diversity of invertebrates at this location decreased from the highest ($H' = 1.11$) of any location in June to the lowest ($H' = 0.85$) in August (Table 15). The invertebrate taxa found at Five Island secondary channel were most similar to those at Candiani secondary channel and least similar to those at Lambert Slough during both sampling periods (Table 16).

84. The only taxa found exclusively at Five Island secondary channel were Paralauterborniella and Kiefferulus.

85. Candiani. The density of benthic invertebrates at Candiani secondary channel was moderately low relative to the other locations, ranking fourth (8,227) in June and fifth (5,971) in August (Figure 11). However, the number of taxa collected ranked high: first (47) for the August sampling period and second (46.5) for the average of the two periods combined. The taxa comprising the majority of the samples in June were Endochironomus (30%), Oligochaeta (21%), Chironomus (9%), Juga (9%), and Fluminicola (7%) (Table 12). Fluminicola was the most abundant taxa in August (33%), followed by Juga (25%), Sphaeriidae (23%), and Oligochaeta (5%) (Table 13).

86. Glossosoma was collected in significantly higher densities at Candiani secondary channel than at any other location during both sampling periods (Table 14). Similarly, Juga and Fluminicola were more numerous during June, and Dina, Ephemerella, and Hydropsyche were more abundant during August at this location than at any other.

87. Stenonema was absent from Candiani secondary channel in June. It was the only widespread (present in at least five locations) taxon present during either sampling period that was least abundant at this location (Table 14).

88. The diversity of invertebrates at Candiani secondary channel was similar in the two sampling periods, with H' values of 1.04 and 1.03, ranking third and fifth in June and August, respectively (Table 15). The invertebrate composition at this location was most like that of Five Island secondary channel in June and Five Island natural bank in August, and least like that of Lambert Slough for both sampling periods (Table 16).

89. Three taxa, Epeorus, Robackia, and Hydrobaenus, were collected only at Candiani secondary channel, and each was found there only during June.

Abandoned Channel

90. Lambert Slough supported the highest densities of invertebrates of all locations except the revetments. In June, 9,959 invertebrates representing 39 taxa were collected; 9,870 individuals representing 47 taxa were collected in August (Figures 10 and 11). Oligochaeta and Procladius were the most abundant taxa at Lambert Slough during both sampling periods (Tables 12 and 13). There was, however, a change in the relative importance of the two as Oligochaeta dropped from 60% of the invertebrates in June to just 22% in August, while Procladius increased from 12% in June to 26% in August.

91. Several taxa were significantly more abundant at Lambert Slough than at any other location, including: Dubiraphia larvae and Cladopelma during both sampling periods; Bezzia-Probezzia and Procladius in June; and Nematoda, Caenis, Sialis, Chironomus, Unionicola, and Chaoboridae in August (Table 14).

92. Many widespread (present in at least five locations) taxa were found to be absent or least abundant at Lambert Slough. These taxa were: Nematomorpha, Manayunkia, Tricorythodes, Stenonema, Cheumatopsyche, Lebertia, Rheotanytarsus, and Orthocladus-Cricotopus during both sampling periods; Branchiobdellida, Anisogammarus, Serratella, Ephemerella, Heptagenia, Pseudocloeon, Hydropsyche, Tricoptera pupae, Cricotopus, Paratanytarsus, and Thienemanniella in June; and Ceraclea, Palpomyia, Polypedium, and Juga in August (Table 14).

93. The diversity of invertebrates increased from June to August at Lambert Slough, being the lowest ($H' = 0.72$) of any location in June and the second highest ($H' = 1.09$) in August (Table 15). The taxa from Lambert Slough were the least similar to those from every other location, and scored the lowest average similarity index in both June and August. The locations with taxa most similar to those of Lambert Slough were Stoutenberg revetment in June and Candiani secondary channel in August. The taxa of the two natural bank locations were least similar to those of Lambert Slough during both sampling periods (Table 16).

94. More taxa (20) were found exclusively at Lambert Slough than for any other location. These taxa were: Turbellaria, Erpobdella, Asellus, Arrenurus, Piona, Isotomidae, Hexagenia, Caenis, Coenagriidae, Ischnura, Homoptera, Sialis, Sisyr, Oecetis, Dubiraphia (adults), Bezzia-Probezzia, Cladopelma, Glyptotendipes, Psectrotanypus, and Gyraulus.

Velocity and Sampling Period Effects

95. The abundances of 15 taxa of benthic invertebrates were significantly affected by water velocity according to the results of the analysis of covariance (Table 14). The taxa associated with fast water included Rhithrogena, Glossosoma, and Simulium for both sampling periods; Palpomyia, Parargyractis, and Corbicula during June; and Hydropsyche during August. The taxa associated with moderate or slow water currents such as the revetments and the pools in the secondary channels include Atractides, Stempellinella, Nematomorpha, and Endochironomus in June and Paracladopelma, Cryptochironomus, and Sphaeriidae in August. The taxa associated with slow or still water currents such as Lambert Slough or the pools in the secondary channels include Chironomus in June and Ablabesmyia in August.

96. The abundances of 15 taxa of benthic invertebrates differed significantly between the June and August samples according to the results of the analysis of variance (Table 14). The taxa that increased in abundance included Ceraclea, Antocha, Polypedilum, and Fluminicola. The taxa that decreased in abundance were Oligochaeta, Anisogammarus, Pacifastacus, Serratella, Ephemerella, Bezzia-Probezzia, Paratanytarsus, Dicrotendipes, Nanocladius, Tanytarsus, and Potthastia.

PART IV: DISCUSSION

Habitat Characteristics

Revetments

97. Revetments resulted in several physical changes in the riverine habitat, particularly in terms of the substrate and water velocity. Revetments were composed of large rocks with numerous interstitial spaces, as compared to gravel or sand and silt constituents at nonrevetted sites. Velocities were moderate (26-72 cm/sec) and fairly uniform throughout each revetted location. Another notable characteristic of the revetments was the uniformly steep shoreline gradient that limited the area of shallow water habitat.

Natural Banks

98. Natural banks were most heterogeneous than the revetments. Bottom types included gravel at Five Island natural bank, and sand and silt at Candiani natural bank. Water velocities were more variable and were faster than at the revetments (46-123 cm/sec). Five Island natural bank had a gentle shoreline gradient which resulted in extensive shallow water habitat. However, the eroding bank at Candiani was irregular, steep, and limited in the amount of shallow water habitat.

Secondary Channels

99. Secondary channels were the most heterogenous in terms of water velocity and substrate. Water velocity ranged greatly from slow pool areas (e.g., 0 cm/sec) to the fast shallow areas (e.g., 123 cm/sec). Bottom types were primarily gravel, except in the pools which contained silt and sand as well. Both secondary channels were narrower than the main river. Other characteristics of the secondary channels that were not found in the habitats of the main river were the thick, overhanging shoreline vegetation and the abundance of woody debris such as submerged logs and fallen trees.

Physical and Water Quality Characteristics

Revetments, Natural Banks, and Secondary Channels

100. Water quality parameters were homogeneous throughout riverine habitats (revetments, natural banks, and secondary channels) examined in this study. The various types of riverine habitat did not differ in measures of water temperature, dissolved oxygen, turbidity, pH, oxidation-reduction potential, or conductivity. This may have been due to relatively high flow rates in the Willamette that did not allow sufficient time for changes to develop over short distances.

Abandoned Channel

101. Lambert Slough had different physical and water quality characteristics as compared to the riverine locations because of a lack of flow through the slough during the time of the study. The main physical differences were a lack of water current and the degree of silt and sand in the substrate (Appendix C). Like the secondary channels, the shoreline of Lambert Slough was lined with overhanging terrestrial vegetation, and submerged logs and snags were scattered throughout. Water temperature in Lambert Slough may be a limiting factor to cool-water fishes since it was 1-2° C higher than the main river in August. Dissolved oxygen was low (<5 ppm) in some sections of the slough, primarily in the deeper areas, as recorded in June, and this may affect the distribution of organisms.

Distributional Patterns of Aquatic Organisms

Revetments

102. Assemblages at the revetments were characterized by high densities of smaller fishes, but species richness and diversity were lower than at the natural banks. Abundance of smaller fishes at the revetments may have been a result of the moderate water current and/or the presence of the interstitial spaces (Hunt 1968; Menzel and Fierstine 1976; Winger et al. 1976). Small fish generally prefer less water current than do larger fish of the same species, and small fish may be more successful at foraging for food and avoiding predation within the interstitial spaces.

103. Most fishes at the revetments, including young northern squawfish, reidside shiner, and prickly sculpin, are generally bottom oriented and feed primarily on invertebrates. Largescale sucker and chiselmouth are also bottom oriented but their diet includes algae and diatoms along with invertebrates. The riprap affords substrate for diatom growth. Piscivorous fishes were occasionally found at the revetments, among them yellow bullhead, northern squawfish adults, and smallmouth bass, although each of these species will also utilize invertebrates as part of their diet.

104. The diversity of benthic invertebrates at revetments was comparable to that of nonrevetted locations in spite of greater numbers of benthic invertebrate taxa supported by the revetments. Comparison of the diversity values may be misleading since the values are all close to each other and the values for invertebrates are based on taxa and not species.

105. Several physical factors of revetted banks may contribute to the higher densities of invertebrates. First, large rocks provide a variety of microhabitats for the organisms by creating numerous interstitial spaces and large surface areas. The crayfish, Pacifastacus, and the aquatic caterpillar, Parargyractis, are examples of organisms that benefit from these two characteristics. Another factor benefiting benthic invertebrates is the stability of the revetments (Solomon et al. 1975; Johnson et al. 1974; Menzel and Fierstine 1976). Nonrevetted locations are subject to bank erosion, which could displace organisms or make the microhabitats unsuitable for survival or reproduction. Benthic invertebrates at revetments may also benefit from the moderate water currents and the protection afforded by large rocks and their interstitial spaces. These two characteristics may reduce the susceptibility of the benthic invertebrates to become displaced and drift with the current.

106. The functional groups represented by invertebrate taxa at the revetments included grazers, scrapers, filter feeders, and scavengers. The grazers and scrapers included numerous genera of Ephemeroptera, Tricoptera, and Chironomidae, as well as the lepidopterid Parargyractis. These herbivorous genera probably forage on the large surface areas of the rocks. The filter feeders include Manayunkia, Hydropsyche, and Cheumatopsyche, all of which attach to the substrate and capture food with either tentacles or nets. The scavengers include the crayfish Pacifastacus and the amphipod

Anisogammarus. Both of these genera probably benefit from the interstitial spaces at the revetments, as they prefer to stay hidden during the day. The Branchiobdellida, which are commensal with crayfish, were also more abundant at the revetments than at the other locations.

Natural Banks

107. The heterogeneity of the natural bank habitats promotes greater diversity and species richness of aquatic organisms, but it supports lower densities of organisms than the more homogeneous revetted habitats. The natural bank locations had greater numbers of fish species than did other locations, and the diversity of benthic invertebrates at Five Island natural bank was high in August. The range of water velocities and substrates at the natural banks was greater than at the revetments and may have contributed to the greater number of fish species found there. Water velocities were comparable between the two natural bank locations, but the eroding bank at Candiani may have affected the composition of the fish community by changing the substrate and reducing the shallow water habitat. Candiani natural bank supported fewer, but larger, fish than did Five Island natural bank. Most of the fishes captured at Candiani were largescale suckers and northern squawfish, both large fish common throughout the study area. Other species collected there were either uncommon or represented by single fish, suggesting that Candiani natural bank was not preferred habitat for those species. The smooth sand and silt bottom and the lack of shallow water habitat may not be suitable for juvenile fishes and many smaller lotic fishes that normally seek the slower water velocities along irregular rock bottoms or the shallow margins along shore.

108. The fish community at Five Island natural bank was unusual in two respects. First, the fish were very small, probably because the water was very shallow. Second, several species commonly associated with tributaries of the Willamette were more abundant here than in the other locations. These fish, including torrent sculpin, mountain whitefish, mountain sucker, and cutthroat trout, probably benefit from the swift, shallow water and gravel bottom which resembles that of the tributary streams.

109. The dominant fish at Candiani natural bank were the primarily herbivorous largescale sucker and the omnivorous northern squawfish. Neither relies entirely on benthic invertebrates for its diet, which may account for the high densities of these species at Candiani as well as the low densities of other species. Insects dominate the diets of the two most abundant species at Five Island natural bank--leopard dace and juvenile northern squawfish. The other abundant species at Five Island--chiselmouth, mountain sucker, and largescale sucker--are herbivorous grazers.

110. The community of fish at Five Island natural bank included several unique, predominant species that were rarely found in other sites. Also, the similarity indices for fishes were relatively low, suggesting that the fish assemblage at Five Island natural bank was not similar to the assemblages at the other locations. Only Lambert Slough had a more unique fish assemblage.

111. In contrast, Five Island natural bank supported only two unique taxa of benthic invertebrates and, except for Eukiefferiella, the major taxa are common at other locations. Bank erosion causes degradation of habitat, displacement of organisms, and change in sediment type. It is probably responsible for the lower number of taxa and the lower abundance of organisms at Candiani as compared to the Five Island natural bank. Because the substrate is composed of fine silt and sand, the flow of oxygenated water through the substrate is reduced. This affects both the abundance of organisms and the maximum depth in the substrate at which they can occur. Also, organisms have difficulty attaching to the silt and sand substrate in fast water. Organisms that appeared to be adversely affected by erosion include cricopoterans, gastropods, and pelecypods.

112. The most abundant taxa at Candiani natural bank were herbivorous chironomids, the particle-feeding oligochaetes, and the parasitic Nematomorpha. The abundant taxa at Five Island natural bank were herbivorous chironomids and particle-feeding oligochaetes. Other herbivores at Five Island included the net-building Cheumatopsyche, grazers such as Fluminicola, and the scraper Glossosoma.

Secondary Channels

113. Fish and invertebrate populations in the secondary channels were surprisingly low in terms of abundance, diversity, and the number of taxa.

Relatively high values for these parameters were expected because of the wide variety of water velocities and substrates found in the secondary channels.

114. Catches of fishes in the secondary channels were low in number of individuals and number of species compared to the other locations. The species compositions were not particularly distinctive, as only one unique species was collected and catches at both locations were dominated by the most common species in the river--northern squawfish and largescale sucker. One factor that may have reduced the catches in the two secondary channels was the inability to maneuver among the partially submerged logs and overhanging shoreline vegetation, which precluded electroshocking in the slower, shallower water close to shore where smaller fish are generally more abundant. Several small species were more abundant in catches from the revetted and natural bank habitats than from the secondary channels. These include redbside shiner, mountain sucker, speckled dace, leopard dace, prickly sculpin, and torrent sculpin. Numerous partially submerged logs and overhanging vegetation provide excellent habitats for smaller species and juveniles, not to mention ambush type predators such as rainbow trout, cutthroat trout, and largemouth bass. Unfortunately, the electroshocker could not be maneuvered to adequately sample these microhabitats. In spite of low numbers of fish caught, the number of species and species diversity were relatively high in Candiani secondary channel, which had fewer submerged logs and obstructions, making it possible to work the electroshocker closer to shore.

115. The species that were present in the secondary channels corresponded to a wide range of water velocities. Besides the northern squawfish and largescale sucker, the native species found in the secondary channels included peamouth, redbside shiner, prickly sculpin, chiselmouth, rainbow trout, chinook salmon, and mountain whitefish. Introduced species included yellow bullhead, brown bullhead, and bluegill. These species may have been associated with slower waters along the shorelines or in the pools. Like the fish population at Candiani natural bank, the species composition in the secondary channels was dominated by the herbivorous largescale sucker and the omnivorous northern squawfish. Most of the other species rely on benthic invertebrates as a food source, except for chiselmouth which are herbivorous.

116. Benthic invertebrate densities in the secondary channels were relatively low compared to other habitat types. Diversities of taxa were relatively high in June compared to other locations, but declined in August when Fluminicola, Sphaeriidae, and Juga dominated the taxa compositions. These three taxa and Corbicula were more abundant in the secondary channels than in the other locations for both sampling periods. The cause of this distribution pattern may be related to the physical characteristics of the secondary channels such as fast, shallow water, gravel substrate, and increased proportions of shade. Pennak (1978) stated that Gastropoda and Pelecypoda are generally found in shallow aquatic habitats, but he believed the reason for this was related to food availability, which is generally higher at the shallower depths. Although the average depth of the secondary channels was generally less than that of the main river, the depths at the sampling stations were comparable because of their proximity to the shore (Table 3).

117. The benthic invertebrates in the secondary channels were primarily herbivorous, as they were at Five Island natural bank, which has a similar substrate and swift, shallow water. These herbivores include chironomids, grazers such as Fluminicola and Juga, scrapers such as Protophila and Glossosoma, net builders such as Hydropsyche and Cheumatopsyche, and the filter-feeding Sphaeriidae and Corbicula.

Abandoned Channel

118. The fish and invertebrate populations in Lambert Slough were the most unique among all locations. The biological difference is most likely the result of Lambert Slough's unique physical characteristics compared to the lotic habitats. The fish population was characterized by fish of large size, as indicated by the high total weight. In spite of low numbers and a low species diversity, several fish species were either unique to Lambert Slough or were most abundant there. This is reflected in the low similarity indices. The differences noted between the fish species composition of Lambert Slough and the lotic locations were consistent with the findings at reservoirs of the Columbia River (Hjort et al. 1981). Two of the predominant species in Lambert Slough, largescale sucker and northern squawfish, apparently have very broad water velocity preferences since they were found

in all of the locations of this study. Almost all of the other fishes in Lambert Slough, including largemouth bass, white crappie, black crappie, carp, bluegill, and warmouth, are introduced species. As a whole, these species prefer lentic habitat much like that found in Lambert Slough. The presence of overhanging shoreline vegetation and the logs and fallen trees in the water should provide good cover for bluegill and warmouth as well as for ambush predators such as the crappie species and largemouth bass. Silt bottoms are preferred by warmouth, black crappie, and carp, to name a few (Wydoski and Whitney 1979; Moyle 1976).

119. The fish community in Lambert Slough appears to be trophically more complex than those of the lotic habitats. In addition to the herbivorous largescale sucker and the omnivorous northern squawfish and carp, there are piscivorous largemouth bass, white crappie, black crappie, and channel catfish, and insectivorous bluegill and warmouth.

120. Lambert Slough supported the highest densities of benthic invertebrates of all the nonrevetted locations. The invertebrate population at Lambert Slough was very different from that of the other habitats in this study. Numerous taxa were most abundant in Lambert Slough or were found there exclusively. Lambert Slough was the location of least abundance for many taxa common to the other locations. In addition, the invertebrate composition in Lambert Slough was the least similar to the other locations (Table 16).

121. Differences in species composition between Lambert Slough and the lotic locations can be attributed to differences in water velocity, water quality (Tables 1 and 2), substrate composition, and organic content of the substrate (Appendix C). Many of the taxa that were most abundant in or exclusive to Lambert Slough are commonly associated with low water velocities. Among them are Caenis, Hexagenia, Ischnura, and Chironomus (Pennak 1978). Turbellaria and Isotomidae are associated with organic debris (Pennak 1978). Most of the widespread taxa that were absent from Lambert Slough were genera from Tricoptera or Ephemeroptera, which are usually associated with flowing water.

122. As with fish, the benthic invertebrate populations in Lambert Slough appear to be more complex trophically than those of the lotic locations. Most of the common invertebrates in the lotic locations were herbivores, with some scavengers at the revetments. The benthic

invertebrates at Lambert Slough included these two groups as well as numerous predators. Herbivores included Dubiraphia, Oecetis, Caenis, Gyraulus, and the filter-feeding Hexagenia. Scavengers included Turbellaria, Helobdella, and Asellus. Predatory taxa in Lambert Slough were Odonata, Sialis, Procladius, Hydracarina, and Chaoboridae. The Helobdella and Hydracarina may also be parasitic. Another common taxon in Lambert Slough was the particle-feeding oligochaetes.

Physical Impacts at Revetments

123. The total impact of revetments on the aquatic habitat is difficult to assess because this study lacked a true control: a stream with few or no revetments. It is difficult to determine whether or not cumulative impacts of many revetted banks affected the fauna at so-called "natural banks." The short-term effects, as determined from this study, may be beneficial for some aquatic fauna; however, the long-term effects may be detrimental (Stern and Stern 1980). The main short-term effects include increased densities of fish and benthic invertebrates and increased stability of aquatic habitat. Habitat stability is one of the factors contributing to the greater abundances of aquatic organisms at revetments (Solomon et al. 1975; Johnson et al. 1974; Menzel and Fierstine 1976). The presence of interstitial spaces and reduced water velocities may also be contributing factors. The instability of Candiani natural bank is a common occurrence in a river which meanders naturally. The lower fish and benthic invertebrate abundances and diversities at Candiani natural bank are probably the result of this instability and reflect a short-term loss as new habitat develops. Eventually, the erosion at Candiani natural bank should cease when the channel configuration is such that the river expends its energy evenly. When this occurs, the bank should stabilize and the abundance and diversity of aquatic organisms should increase. Revetments, on the other hand, should not be subject to the short-term fluctuations in abundances and diversity caused by habitat instability. Of course, there may be fluctuations in invertebrate densities at revetments due to other factors such as changes in flow. The density of benthic invertebrates was much lower at Weston revetment in August than it was in June.

124. The long-term effects of revetments include a reduction in the area and diversity of the aquatic habitat by restriction of the river channel (Johnson et al. 1974; Funk and Robinson 1974). Revetments are installed to reduce bank erosion and restrict movement of the river channel. This restriction is demonstrated in Figure 12, which shows the upper Willamette River as traced from two U. S. Geological Survey maps dated 1910 and 1967. This section of the Willamette River, from the McKenzie River to Harrisburg, had a highly braided channel in 1910. Construction of revetments in this section of the river began in 1938, and all of those completed by 1967 are shown in Figure 12.

125. Revetments appear to have been responsible for constraining and guiding the river into what is primarily a single channel. This has resulted in the loss of secondary channels and will reduce the long-term formation of abandoned channels. Secondary and abandoned channels add habitat area and diversity to a section of river. During the study period, for example, no water current flowed through Lambert Slough. As a result, Lambert Slough had the most unique fish and benthic invertebrate populations of all the locations.

126. The secondary channels also added habitat diversity because they had physical characteristics different from the main river. They were narrower and had a wider range of water velocities (Table 3). The secondary channels also had a higher proportion of shade because of the narrower stream width and overhanging vegetation. The natural bank locations and the secondary channels both had a wider range of water velocities, depths, and substrate types than the revetments, which were relatively homogeneous within and between locations.

127. Another long-term impact of revetments is the reduction of shallow water habitat. The steep shoreline gradient of the revetments reduces the width of the shallow water habitat that may be important to larval and juvenile fishes. Short-term loss of shallow water habitat occurs at eroding banks such as Candiani natural bank; however, the shallow water habitat should be reestablished when the erosion stops, allowing the bank to stabilize. Results from Hjort et al. (1981) indicate that the nearshore areas are important nursery habitats for larval fishes, and LaBolle (1983) has shown that the densities of larval fishes decrease with distance from

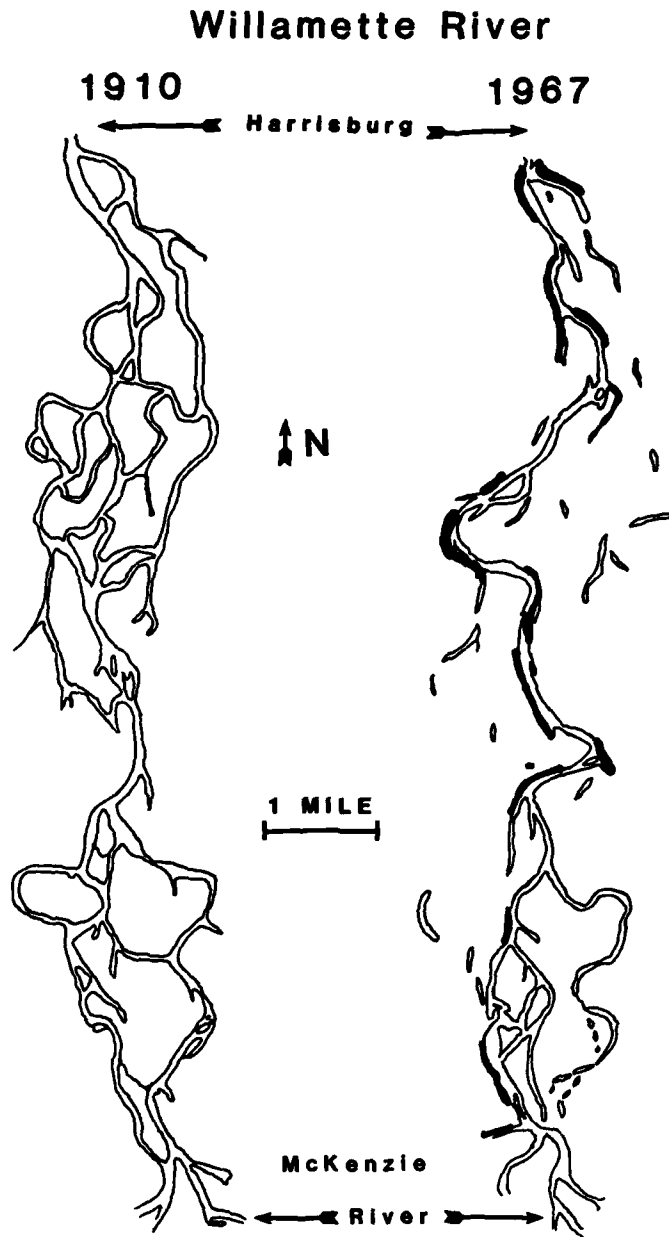


Figure 12. Outlines of the Willamette River between the mouth of the McKenzie River and Harrisburg, Oregon, as traced from U. S. Geological Survey maps surveyed in 1910 and 1967. The heavy lines on the 1967 map are revetments that were present before 1967. Direction of flow is to the north

shore within the nearshore area. The loss of the shallow water areas of revetments may be mitigated by moderate water velocities and the presence of interstitial spaces. The shallow water areas are also important spawning areas for some fish species. The large substrate and moderate water velocities at the revetments may not be suitable for fish species that require fast water and gravel substrate for spawning.

Individual Fish Species Distributions

128. Three basic fish species distribution patterns were observed: native species with general habitat preferences, native species with specific habitat preferences, and the introduced species. The first group includes the largescale sucker, northern squawfish, peamouth, and chiselmouth. These are large mobile fish that apparently have broad habitat preferences. Largescale suckers, for instance, dominated the catch totals at Candiani natural bank, Candiani secondary channel, and Lambert Slough. These habitats included both fine silt and gravel substrates, and water velocities ranging from 0 to 123 cm/sec. The habitat preferences of the other three species, although not as broad as the largescale sucker, were still widespread. Peamouth were collected in all habitat types but were not abundant enough to draw conclusions about habitat preferences. Northern squawfish and chiselmouth were both more abundant in the lotic habitats than in Lambert Slough.

129. The second group of native species had very specific distribution patterns. Several of these species are generally found in faster, cooler waters more common to the tributaries of the Willamette River. Among these species were cutthroat trout, rainbow trout, torrent sculpin, mountain whitefish, mountain sucker, and chinook salmon juveniles. Most of these fish were collected at Five Island natural bank, which had fast currents and shallow depths. Of the other native species with distinctive patterns of distribution, reddsideshiner and speckled dace were common to revetments, and leopard dace were most abundant at Five Island natural bank.

130. The introduced species were most abundant at Lambert Slough. They included largemouth bass, bluegill, warmouth, black crappie, and white crappie, which are commonly associated with lakes and ponds, habitats that are similar to Lambert Slough. The only introduced species that were more common in the lotic habitats were yellow bullhead and one smallmouth bass, which were collected at the revetments.

Patterns of Invertebrate Taxa Distribution

131. The composition of the invertebrate taxa varied greatly among locations. Obvious factors affecting distribution include differences in water velocity, substrate, depth, and organic detritus. The response of various taxa to patterns of water velocity, substrate, and organic detritus was discussed earlier. Undoubtedly, depth also plays a role, but it was not a major consideration of this study. The depth at each station was chosen to be comparable, except at Lambert Slough that had a more U-shaped cross section. However, it is difficult to determine what role depth played in the distribution of invertebrate organisms when comparing Lambert Slough to the other locations because differences in velocity and substrate confound the pattern.

132. Another factor which affects the distribution of organisms is high winter flows. The presence of overhanging vegetation in the secondary channels and Lambert Slough suggests that little winter scouring occurs there. Predominant taxa at natural banks were chironomids. These taxa were able to rapidly colonize an area or were able to exploit habitats deep in the substrate, thus protected from scouring and high water velocities. Predominant taxa at revetments were organisms that were attached to the substrate, such as Manayunkia speciosa, or were protected within the interstitial spaces, as was Anisogammarus. Predominant taxa in the secondary channels included Juga and Sphaeriidae, both of which could be dispersed by high water velocities and scouring. Lambert Slough was so different from the main river that its taxonomic assemblage was unique. Several of the predominant taxa were larger organisms, suggesting that they have longer life cycles and could not reestablish quickly if flushed out by high winter flows.

Comparisons with Past Studies

133. Twenty-eight fish species were captured during this study, including several not previously reported by Dimick and Merryfield (1945) or Noble (1952). These species were rainbow trout, mountain whitefish, smallmouth bass, channel catfish, warmouth, prickly sculpin, reticulate sculpin, and banded killifish. Dimick and Merryfield (1945) and Noble (1952) captured or reported 14 species each for a total of 21 species in their study areas, both located 6 miles upstream from the area of this study.

The only species they reported that was not collected in this study was the longnose dace (Rhinichthys cataractae).

134. There were several explanations for the greater species numbers captured in this study. First is the differences in gear types. Earlier workers relied primarily on seines and hook-and-line, compared to electroshocker and hoopnets used in this study. Data from one of our studies on Columbia River reservoirs suggest electroshockers will capture more species than seines (Hjort et al. 1981). Second, this study included several different habitat types (revetments, secondary channels, natural banks, and an abandoned channel) while the others were limited to areas where seines were most effective. Third, the Willamette River has undergone a dramatic change since the time of the previous studies (Gleeson 1972). At the time of the Dimick and Merryfield (1945) and Noble (1952) studies, the Willamette River had higher levels of pollutants and lower late-summer flow levels. Several of the species not captured before are sensitive to pollutants and may have been absent or less abundant during their studies. These species include prickly sculpin, reticulate sculpin, rainbow trout, mountain whitefish, and smallmouth bass. Another species captured in this study, the banded killifish, was added to Oregon's fish species list because it confirmed an earlier capture of this species*; thus, this species most likely was not formerly present.

* Personal communication, 1982, Carl Bond, Professor, Department of Fisheries and Wildlife, Oregon State University.

PART V: SUMMARY

135. Revetments affect many aspects of fish habitat in the Willamette River including habitat diversity, abundance of benthic invertebrate prey, benthic community structure, water velocities, substrate size, total available habitat, and habitat stability. These factors determine, in part, the abundance, size, species diversity, and richness of fishes.

136. Impacts of the revetments are mixed. Higher densities of aquatic organisms were found at revetted sites, but species richness and diversity were not necessarily higher. Although not addressed in this study, casual observations indicate that revetments may provide good rearing habitat and protective cover because of the interstitial spaces and slower currents in these spaces. These characteristics may be especially important during high winter flows. A third benefit is an increase in habitat predictability/stability.

137. In theory, the fish and benthic invertebrate populations at revetments should be relatively stable from year to year compared to nonrevetted locations that might be subject to habitat degradation and change. An example of this problem was the low densities of fish and benthic invertebrates at Candiani natural bank where there was a severe erosion problem.

138. In spite of these benefits, the long-term impact of revetments on fish and invertebrate populations may be detrimental because revetments restrict channel movement and constrict the channel. Revetments eliminate the natural processes that result in multiple channels and abandoned channels. Thus, there is a potential for loss of total habitat area. However, estimates of the total losses of habitat compared to the increase in density of fishes and benthic invertebrates at the revetment sites are beyond the scope of this study.

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APPENDIX A: FISH CATCHES FROM ELECTROSHOCKING AND HOOPNET SETS ON
RIVER MILES 58-66 OF THE WILLAMETTE RIVER, OREGON,
JUNE AND AUGUST 1982

Table A1. Catch by species of fish collected by electroshocking 21 transects in seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 9-11, 1982.

Species	Revetted Banks						Natural Banks						Secondary Channels						Abandoned Channel		
	Stoutenberg			Weston Bend			Five Island Bar			Candiani Bar			Five Island Bar			Candiani Bar			Lambert Slough		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Carp	28	32	23	18	7	8	4	9		2			5	1	2	7			1		2
Northern squawfish																					
Peamouth													1			1	2		1		
Chiselmouth	7	4	3	6	2	1						1									
Largescale sucker	9	6	6	9	3	1	5	3		12	4	13	2	4	5	5	12	9	22	4	5
Mountain sucker							4	6				1									
Redside shiner		4			2	2				1		2									
Speckled dace	1	1	3	1	3	4	2		4												
Leopard dace							6	4	59												
Mountain whitefish							3														
Chinook salmon				1	1					1		1	1	1		1					
Rainbow trout					1	1									1						
Cutthroat trout								2													
White crappie																			2	1	1
Smallmouth bass	1																				
Largemouth bass										1									3	3	6
Bluegill																					1
Channel catfish																					1
Yellow bullhead						1															
Prickly sculpin	7	4	7	2	10	9		1										1			
Torrent sculpin							2		6												
Reticulate sculpin	3	1	1	1	1																
Banded killifish						1															
Totals	56	47	47	38	31	27	26	25	69	15	7	17	3	8	11	7	17	23	27	12	15
No. Individuals	7	5	7	7	10	8	7	6	3	4	3	4	2	4	3	3	5	5	3	7	5
No. Species																					

Table A2. Catch by species of fish collected by electroshocking 21 transects in seven locations between river miles 50 and 66 on the Willamette River, Oregon, August 23-25, 1982.

Species	Revetted Banks						Natural Banks						Secondary Channels						Abandoned Channel		
	Stoutenberg			Weston Bend			Five Island Bar			Candiani Bar			Five Island Bar			Candiani Bar					
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Carp																					
Northern squawfish	35	43	22	32	47	36	18	6	15	8	7	13	2	7	8	4	1	4	1	1	1
Peanouth	1	1									1					1	2				
Chiselmouth	1		2	9	5	2	20	2	1			2									
Largescale sucker	2	3	4	3	3	2	3	2	3	2	7	5	5	3	2	2	6	6	9	12	3
Mountain sucker							1	5						1							4
Redside shiner	8	2	3	5	9	6							1			3	1				
Speckled dace				2		2															
Leopard dace										1	4	1									
Mountain whitefish														2			2	2			
Chinook salmon							1													1	2
Largemouth bass																					2
Yellow bullhead						1															
Prickly sculpin	12	3	1	1	1	6															
Torrent sculpin																					
Reticulate sculpin	1	1																			
Totals																					
No. Individuals	60	50	31	53	65	56	42	23	25	15	14	21	8	9	10	14	12	15	15	7	6
No. Species	7	5	5	6	5	7	5	7	5	2	4	4	4	2	2	4	5	3	4	4	2

Table A3. Catch by species of fish captured in hoopnets set at 28 stations in seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 7-8, 1982.

Species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Northern squawfish	2				4					5	2	1	2	2	1													
Chiselmouth								1	1							1												
Largescale sucker					1	2		2				1				10	1	4	2	2		1						
Black crappie																					1							1
White crappie																												
Bluegill									1	1					1	1							1				2	2
Pumpkinseed											1																	2
Warmouth																												11
Brown bullhead																												
Yellow bullhead																												
Lamprey	2																											
Totals																												
No. Individuals	4				1	6	1	3	1	2		1	16	5	1	6	5	3	1	4		1				4	3	16
No. Species	2				1	2	1	2	1	2		1	3	4	1	2	3	2	1	3		1			2	2	3	

Table A4. Catches by species of fish captured in hoopnets set at 28 stations in seven locations between river miles 58 and 66 of the Willamette River, Oregon, August 16-20, 1982.

	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel			
	Stoutenberg				Weston Bend				Five Island Bar				Candiani Bar				Five Island Bar				Candiani Bar				Lambert Slough			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Carp																												
Northern squawfish	3	3			1	2	5	1					6	1	3	1					2	1	1					1
Chiselmouth	1	1	1	7	2			3			1	1	9															
Largescale sucker	1		1		1	1	2	2	1	1			3	1							1				1	3		
Black crappie													1														2	
White crappie																									1	5	1	
Bluegill																										9	4	
Warmouth																										1		
Yellow bullhead					1	2	1	1									1											
Totals																												
No. Individuals	5	4	1	8	3	5	5	11	2		2	1	20	3	3	1					2	3	1		2	21		5
No. Species	3	2	1	2	2	4	3	3	2		2	1	5	3	1	1					1	3	1		2	6		2

Table A5. Total weight (gms) by species of fish collected by electrofishing 21 transects in seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 9-11, 1982.

Species	Revetted Banks						Natural Banks						Secondary Channels						Abandoned Channel		
	Stoutenberg			Weston Bend			Five Island Bar			Candiani Bar			Five Island Bar			Candiani Bar			Lambert Slough		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Carp																					1660
Northern squawfish	2648	2947	2852	2442	621	1288	187	536		484			1252	248	295	2019	10	19			
Pemmouth													310			275	443	7			
Chiselmouth	1075	350	474	612	56	200				115			252	19	233	465					
Largescale sucker	3016	1383	2195	3635	1835	170	1207	1780		6169	2430	7117	1500	1925	3740	2568	7500	5408	12,759	3130	2795
Mountain sucker							23	71		157											
Redside shiner			149		38	52				34		27									
Speckled dace	2	3	5	1	6	7	11		4												
Leopard dace							6	5	58												
Mountain whitefish							4														
Chinook salmon				10	14					10		3400	54		15						
Rainbow trout				95	100										3900						
Cutthroat trout								144													
White crappie																			405	175	105
Smallmouth bass	5																				
Largemouth bass										228									2672	200	361
Bluegill																					25
Channel catfish																			5200		
Yellow bullhead						175															
Prickly sculpin	89	56	104	14	120	227		4										5			
Torrent sculpin							18		43												
Reticulate sculpin	15		4	3	2																
Banded killifish						2															
TOTALS																					
Total weight	6850	4739	5783	6717	2789	2219	1456	2540	105	6441	3071	10,659	1500	2541	5011	6716	8318	8340	15,836	10,382	3305
No. Species	7	5	7	7	10	8	7	6	3	4	3	4	1	4	3	3	5	5	3	7	5

Table A6. Total weight (gms) by species of fish collected by electroshocking 21 transects in seven locations between river miles 58 and 66 on the Willamette River, Oregon, August 23-25, 1982.

Species	Revetted Banks						Natural Banks						Secondary Channels						Abandoned Channel		
	Stoutenberg			Weston Bend			Five Island Bar			Candiani Bar			Five Island Bar			Candiani Bar			Lambert Slough		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Carp																			1000	2560	
Northern squawfish	423	373	739	1884	1925	1110	313	70	102	1834	38	3546	647	885	1730	794	27	2527	55	142	
Pearmouth	94	3									303					105	222				
Chiselmouth	205		530	581	819	25	267	41	8			330									
Largescale sucker	2000		2300	1850	1320	1538	828	1885	6	5750	3535	3405	2025	1425	1550	2765	4019	6685	7370	1290	765
Mountain sucker							27	100					135								
Redside shiner	68	18	25	141	94	126				49				34	7						
Speckled dace				7		4															
Leopard dace									3	13	4										
Mountain whitefish									65	23			30			35	24				
Largemouth bass																			2	361	959
Yellow bullhead																					
Prickly sculpin	150	52	22	6	29	169															
Torrent sculpin									22												
Reticulate sculpin	4	7																			
TOTALS																					
Total weight	2944	453	3616	4469	4187	3292	1435	2186	152	7584	3880	7330	2837	2310	3280	3698	4310	9236	8427	4353	1724
No. Species	7	5	5	6	5	7	4	7	5	2	4	4	4	2	2	4	5	3	4	4	2

Table A7. Total weight (gm) by species of fish captured in hoopnets set at 28 stations in seven locations between river miles 58 and 66 on the Willamette River, Oregon, June 7-9, 1982.

Species	Revetted Banks								Natural Banks								Secondary Channels								Abandoned Channel							
	Scoutenberg				Horton Bend				Five Island Bar				Oardiani Bar				Five Island Bar				Oardiani Bar				Lambert Slough							
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D				
Northern squawfish 1230					1707								1459	1307	1020	1672	1765	300														
Chiselmouth						173	175					310					265															
Largemouth sucker					695	385	148					135	4003	620		2515	1115	960	920													
Black crappie																		165											85			
White crappie																													308	168		
Bluegill									90	135			115	75					94									114		858		
Pumpkinseed										37																						
Warmouth																												177		363		
Brown bullhead																																
Yellow bullhead																			315													
Pacific lamprey					795												795															
TOTALS																																
Total weight	2025	0	0	0	695	2092	173	323	90	172	0	135	0	5577	2312	1020	4187	3145	1260	165	1229	0	0	248	0	291	393	1389				
No. Species	2	0	0	0	1	2	1	2	1	2	0	1	0	3	4	1	2	3	2	1	3	0	0	1	0	2	2	2	3			

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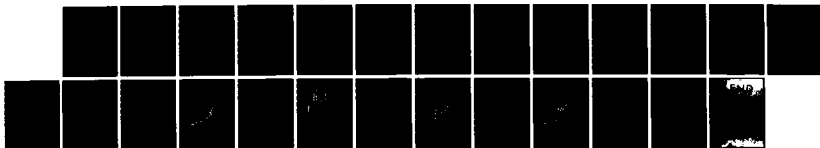
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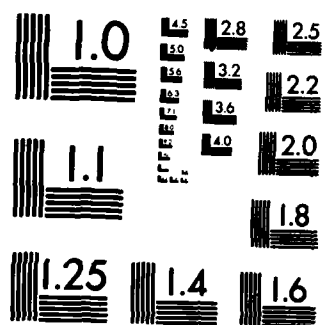


Table A9. Total number of individual fish, total number of species and total weight (grams) for electroshocker and hoopnet catches on the Willamette River, June and August 1982.

	Revetted Banks		Natural Banks		Secondary Channels		Abandoned Channel
	Stoutenberg	Weston Bend	Five Island Bar	Candiani Bar	Five Island Bar	Candiani Bar	Lambert Slough
Total No. Individuals	313	305	219	137	65	99	133
Total No. Species	10	12	13	13	8	12	10
Total Weight	31,238	34,130	17,723	58,545	26,436	44,495	49,212

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Table 31. Continued

Table B1. Continued																																					
PHTUN		Inhabited Banks										Natural Banks										Secondary Channels										Abandoned Channel					
CLASS	ORDER	Stonewall					Weston Bend					Five Island Bar					Candiani Bar					Five Island Bar					Candiani Bar					Lambert Slough					
		A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	
	FORMICIDAE																																				
	HYMENOPTERA																																				
	DIPTERA																																				
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**APPENDIX B: BENTHIC INVERTEBRATE DENSITIES FROM SAMPLES COLLECTED
FROM RIVER MILES 58-66 OF THE WILLAMETTE RIVER,
OREGON, JUNE AND AUGUST 1982**

Table 81. Continued

[illegible]

Table B1. Continued

Fagily	Reverted Banks										Natural Banks										Secondary Channels										Abandoned Channel			
	Stoutenberg					Weston Bend					Five Island Bar					Gradient Bar					Five Island Bar					Gradient Bar					Leahurst Slough			
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E				
Stenilidae (pupae)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae (larvae)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Stenilidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-																		

(Cont. from p. 100)

(Sheet 6 of 5)

Table B1. Concluded

[illegible]

Table B2. Continued

[illegible]

(Sheet 2 of 5)

Table 92. Continued

[illegible]

(Sheet 3 of 5)

Table B2. Continued

[illegible]

(page 100)

(Sheet 4 of 5)

Table 02, Concluded

PARTIAL CLASS ORDER	Revetted Banks										Natural Banks										Secondary Channels										Abandoned Channel			
	Stoutenberg					Weston Bend					Five Island Har					Candiani Bar					Five Island Har					Candiani Bar					Lambert Slough			
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E				
Genus, species																																		
MOLLUSCA																																		
GASTROPODA																																		
JUNE 1966																																		
Neritidae																																		
Planorbicula																																		
Ancyliidae																																		
Pteridella																																		
Planorbidae																																		
Cyclophorus																																		
Margaritiferidae (Paragobio)																																		
Pelecypoda																																		
Margaritiferidae																																		
Gobriculidae																																		
Sphaeritidae																																		
CERDOR																																		
PETROMYXINIFORMES																																		
PETROMYXINIFORMES																																		
Lamprocypridae																																		
Lamprocypridae (Lamprocypridae)																																		
OSTREICHTHYSES																																		
SUCCEANIFORMES																																		
Cottidae																																		
Cottidae																																		
No. Individuals																																		
Station Totals																																		
No. Tans																																		
Location Totals																																		
No. Tans																																		
44																																		
42																																		
6288																																		
7949																																		
2538																																		
4916																																		
5871																																		
9870																																		
47																																		
47																																		

APPENDIX C: SEDIMENT SAMPLE ANALYSES

SEDIMENT SAMPLES RECEIVED FOR LABORATORY ANALYSIS¹

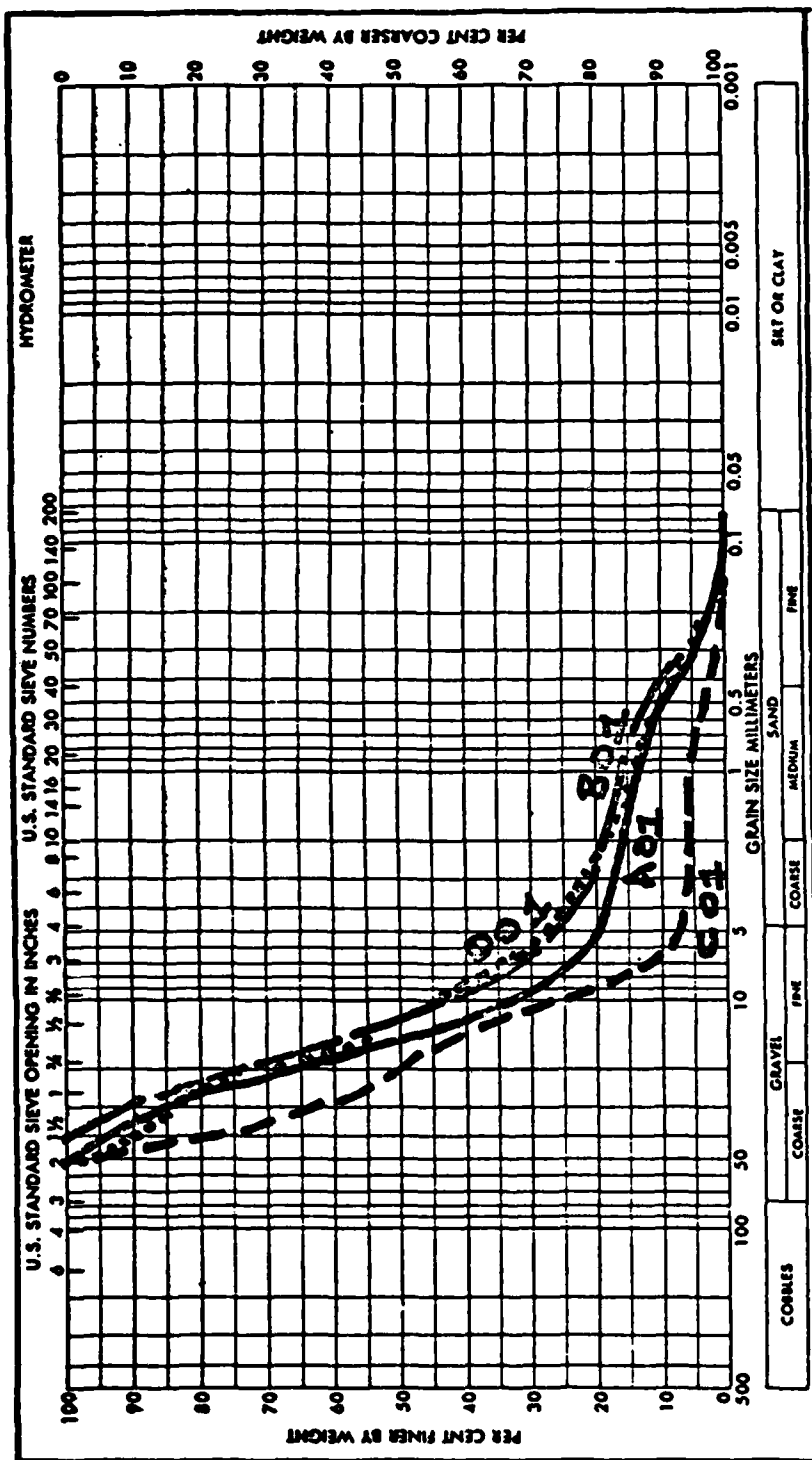
Sampling Location	Approx. RM	Sampling Station	Sampling Date	Sampling Time	Sampling Method	Field I.D. No.	Lab. I.D. No.	Computer Loc. Code
Candiani Side Channel	58.5	(A01)	6/15/82	1030	dredge	05	3	PCC
		B01	6/15/82	1130	scoop/bag	07	4	
		C01	6/15/82	1300	scoop/bag	09	1	
		D01	6/15/82	(1430)	scoop/bag	11	2	
Candiani Main Channel	58.5	D01	6/16/82	0900	(See note 2) #14, 6/16/82 (scoop/bag)	13	14, 17, 18 13	NBC
Five Island Main Channel	62	A01	6/16/82	1325	scoop/bag	21	20	NBF
		B01	6/16/82	1400	scoop/bag	23	15	
		C01	6/16/82	1540	scoop/bag	25	16	
		D01	6/16/82	1705	scoop/bag	27	19	
Five Island Secondary Channel	62	A01	6/17/82	1330	scoop/bag	34	9	PCF
		B01	6/17/82	(1400)	scoop/bag	36	11	
		C01	(6/17/82)	(1220)	(scoop/bag)	32	12	
		D01	6/17/82	--	---	(30)	10	
Lambert Slough	65	A01	6/18/82	(1015)	scoop/bag	44	7	ABS
		B01	6/18/82	0900	scoop/bag	42	8	
		C01	6/17/82	1715	scoop/bag	40	6	
		D01	6/17/82	(1555)	dredge	38	5	

¹ Information tabulated was taken from sample tag (except for river mile (RM) and computer location code) unless shown in parentheses.

² For lab samples 14, 17, 18 the field sample tags were not readable (they had broken in small pieces).

SIEVE ANALYSIS, SEDIMENT SAMPLES FROM WILLAMETTE RIVER, FIVE ISLAND MAIN CHANNEL NEAR RM 62

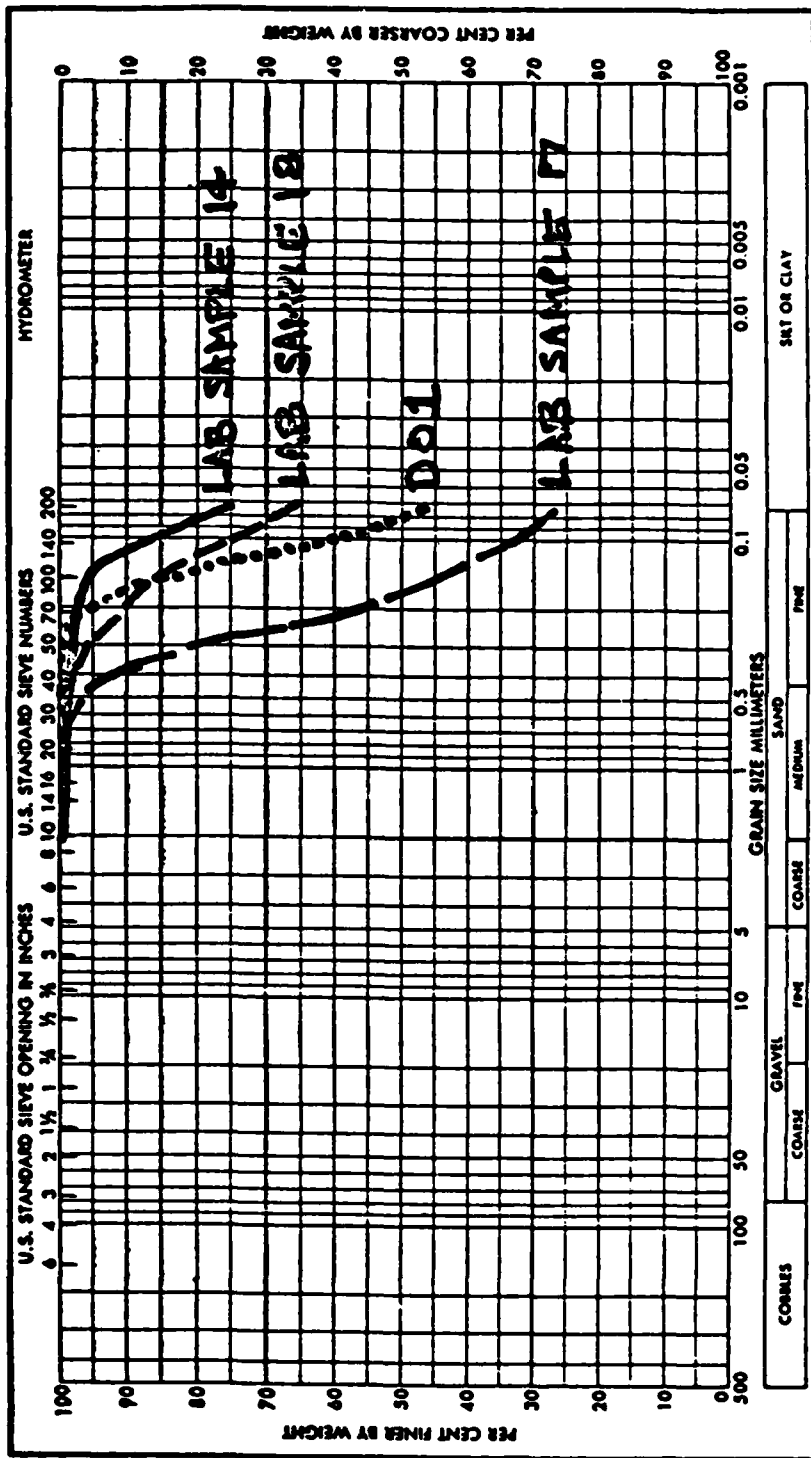
U.S. Standard Sieve Size or Number	A01			B01			C01			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	--	--	--	--	--	--	--	--	--
2-in.	0	0	100.0	--	--	--	0	0	100.0	0	0	100.0
1-1/2-in.	91.8	8.78	91.2	0	0	100.0	217.8	23.27	76.7	111.0	10.28	89.7
1-in.	99.0	9.48	81.7	147.2	14.31	85.7	182.2	19.48	57.3	100.8	9.33	80.4
3/4-in.	194.8	18.64	63.1	154.8	15.04	70.7	69.8	7.45	49.8	174.5	16.16	64.2
1/2-in.	203.0	19.43	43.7	204.0	19.82	50.8	111.2	11.89	37.9	169.0	15.65	48.6
3/8-in.	122.0	11.68	32.0	107.5	10.44	40.4	134.8	14.40	23.5	76.0	7.04	41.5
No. 3	94.2	9.02	23.0	107.5	10.44	30.0	123.0	13.14	10.4	113.5	10.51	31.0
No. 4	32.2	3.09	19.9	47.2	4.59	25.4	28.2	3.02	7.4	47.8	4.42	26.6
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	40.5	3.88	16.0	57.0	5.54	19.8	11.0	1.18	6.2	77.0	7.13	19.5
No. 10	6.8	0.65	15.4	11.0	1.07	18.8	0.8	0.08	6.1	20.2	1.88	17.6
No. 16	12.0	1.15	14.2	18.0	1.75	17.0	1.5	0.16	5.9	31.0	2.87	14.7
No. 20	11.8	1.12	13.1	8.8	0.85	16.2	1.5	0.16	5.8	16.5	1.53	13.2
No. 30	19.8	1.89	11.2	15.2	1.48	14.7	9.0	0.96	4.8	19.0	1.76	11.4
No. 40	28.2	2.70	8.5	38.2	3.72	11.0	16.2	1.74	3.1	29.5	2.73	8.7
No. 50	36.2	3.47	5.0	56.5	5.49	5.5	12.5	1.34	1.7	39.5	3.66	5.1
No. 70	24.8	2.37	2.7	31.2	3.04	2.4	8.0	0.85	0.9	29.8	2.76	2.3
No. 100	18.0	1.72	0.9	18.0	1.75	0.7	5.5	0.59	0.3	18.2	1.69	0.6
No. 140	5.5	0.53	0.4	5.2	0.51	0.2	1.5	0.16	0.1	4.8	0.44	0.2
No. 200	1.8	0.17	0.2	1.2	0.12	0.1	0.8	0.08	0.1	1.2	0.12	0.1
Pan	2.5	0.24	0.0	0.5	0.05	0.0	0.5	0.05	0.0	0.5	0.05	0.0
Total Weight, grams	1044.8	--	--	1029.2	--	--	935.8	--	--	1079.8	--	--



GRADATION CURVES, SEDIMENT SAMPLES FROM WILLAMETTE RIVER,
 FIVE ISLAND MAIN CHANNEL NEAR RM 62

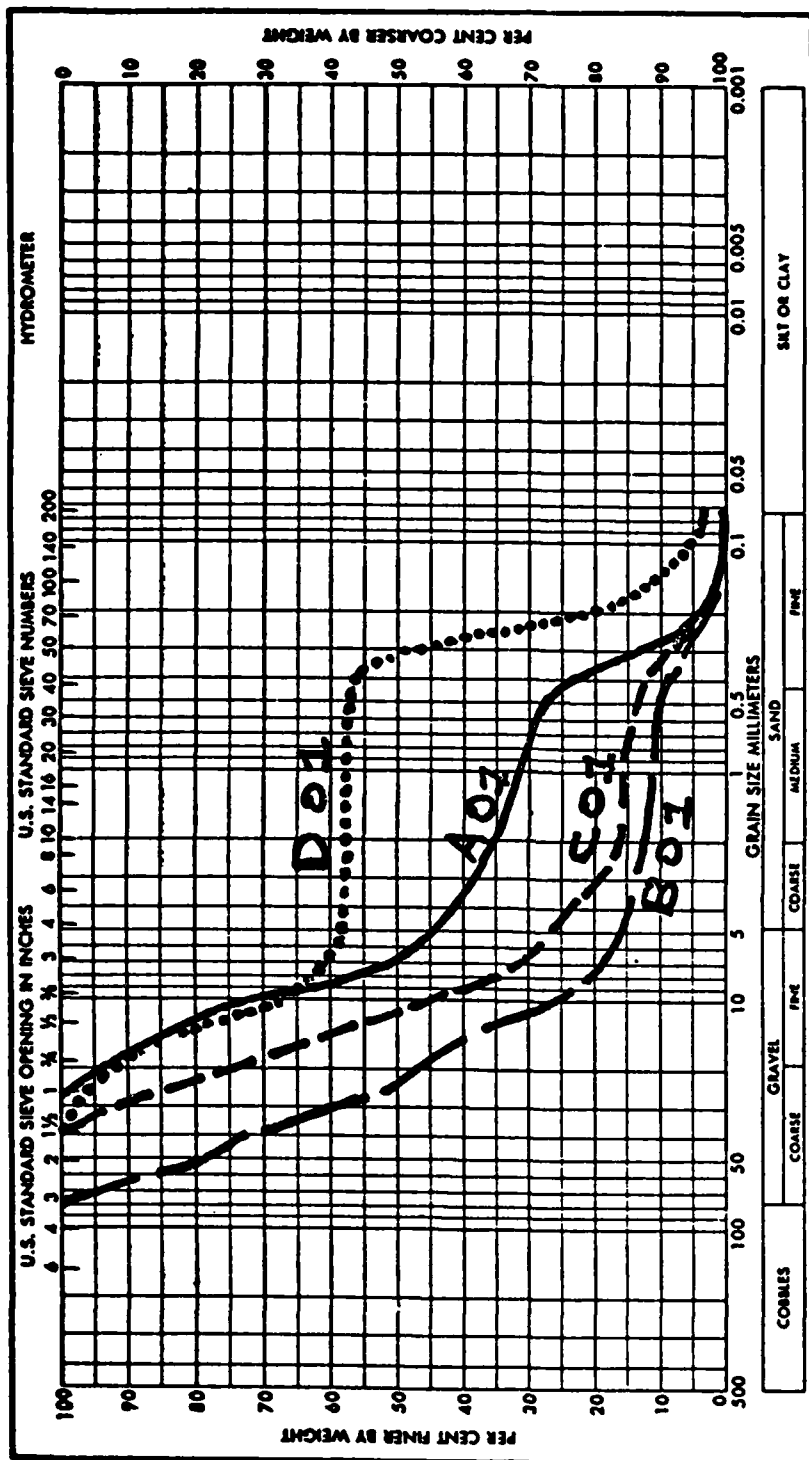
SIEVE ANALYSIS, SEDIMENT SAMPLES FROM WILLAMETTE RIVER, CANDIANI MAIN CHANNEL NEAR RM 58.5

U.S. Standard Sieve Size or Number	LAB SAMPLE 14			LAB SAMPLE 17			LAB SAMPLE 18			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Mt.	Weight Retained, grams	Percent Retained	Percent Finer by Mt.	Weight Retained, grams	Percent Retained	Percent Finer by Mt.	Weight Retained, grams	Percent Retained	Percent Finer by Mt.
3-in.	--	--	--	--	--	--	--	--	--	--	--	--
2-in.	--	--	--	--	--	--	--	--	--	--	--	--
1-1/2-in.	--	--	--	--	--	--	--	--	--	--	--	--
1-in.	--	--	--	--	--	--	--	--	--	--	--	--
3/4-in.	--	--	--	--	--	--	--	--	--	--	--	--
1/2-in.	--	--	--	--	--	--	--	--	--	--	--	--
3/8-in.	--	--	--	--	--	--	--	--	--	--	--	--
No. 3	--	--	--	--	--	--	--	--	--	--	--	--
No. 4	--	--	--	--	--	--	--	--	--	--	--	--
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	--	--	--	--	--	--	--	--	--	--	--	--
No. 10	0	0	100.0	0	0	100.0	--	--	--	--	--	--
No. 16	0.2	0.09	99.9	0.8	0.08	99.9	--	--	--	--	--	--
No. 20	0.5	0.18	99.7	2.5	0.25	99.7	0	0	100.0	--	--	--
No. 30	0.8	0.27	99.5	10.2	1.03	98.6	0.8	0.19	99.8	0	0	100.0
No. 40	0.8	0.27	99.2	40.2	4.03	94.6	2.8	0.69	99.1	1.0	0.10	99.9
No. 50	1.5	0.53	98.7	165.0	16.53	78.1	15.5	3.88	95.2	6.5	0.63	99.3
No. 70	1.2	0.44	98.2	202.0	20.74	57.8	16.0	4.01	91.2	22.5	2.18	97.1
No. 100	4.5	1.59	96.6	116.8	11.70	46.2	17.2	4.32	86.9	125.0	12.13	85.0
No. 140	20.5	7.24	89.4	125.2	12.55	33.6	35.2	8.83	78.1	224.0	21.74	63.2
No. 200	41.2	14.58	74.8	60.0	6.01	27.6	51.8	12.97	65.1	169.5	16.45	46.8
Pan	211.8	74.82	0.0	275.5	27.60	0.0	259.8	65.10	0.0	482.0	46.77	0.0
Total Weight, grams	283.00	--	--	998.2	--	--	399.0	--	--	1030.5	--	--



SIEVE ANALYSIS, SEDIMENT SAMPLES FROM WILLAMETTE RIVER, FIVE ISLAND SECONDARY CHANNEL NEAR RM 62

U.S. Standard Sieve Size or Number	A01			B01			C01			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	0	0	100.0	--	--	--	--	--	--
2-in.	--	--	--	299.0	20.08	79.9	--	--	--	--	--	--
1-1/2-in.	--	--	--	92.0	6.18	73.7	0	0	100.0	0	0	100.0
1-in.	0	0	100.0	307.8	20.66	53.1	214.0	11.95	88.1	33.5	3.14	96.9
3/4-in.	78.0	7.93	92.1	88.0	5.91	47.2	261.0	14.57	73.5	54.0	5.07	91.8
1/2-in.	97.5	9.91	82.2	165.0	11.08	36.1	305.8	17.07	56.4	151.5	14.22	77.6
3/8-in.	162.2	16.49	65.7	145.2	9.75	26.3	262.8	14.67	41.7	113.0	10.60	67.0
No. 3	149.5	15.20	50.5	120.8	8.11	18.2	196.2	10.96	30.8	71.8	6.73	60.2
No. 4	68.0	6.91	43.6	42.8	2.87	15.4	73.0	4.08	26.7	18.2	1.71	58.5
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	71.0	7.22	36.3	32.2	2.17	13.2	176.5	9.85	16.9	6.8	0.63	57.9
No. 10	14.0	1.42	34.9	4.5	0.30	12.9	9.0	0.50	16.4	0.0	0.00	57.9
No. 16	29.5	3.00	31.9	10.8	0.72	12.2	13.0	0.73	15.6	0.2	0.02	57.9
No. 20	6.5	0.66	31.3	7.5	0.50	11.7	5.5	0.31	15.3	0.0	0.00	57.9
No. 30	17.0	1.73	29.5	10.0	0.67	11.0	10.8	0.60	14.7	0.5	0.05	57.8
No. 40	30.5	3.10	26.4	17.8	1.19	9.8	25.2	1.41	13.3	6.0	0.56	57.3
No. 50	114.5	11.64	14.8	44.0	2.95	6.9	74.0	4.13	9.2	89.5	8.40	48.9
No. 70	93.2	9.48	5.3	46.2	3.11	3.8	77.2	4.31	4.9	234.8	22.03	26.8
No. 100	39.5	4.02	1.3	35.0	2.35	1.4	53.0	2.96	1.9	151.8	14.24	12.6
No. 140	8.5	0.86	0.4	11.8	0.79	0.6	20.2	1.13	0.8	69.0	6.47	6.1
No. 200	1.8	0.18	0.3	4.2	0.29	0.3	8.5	0.47	0.3	28.8	2.70	3.4
Pan	2.5	0.25	0.0	4.8	0.32	0.0	5.5	0.31	0.0	36.5	3.42	0.0
Total Weight, grams	983.8	--	--	1489.2	--	--	1791.2	--	--	1065.8	--	--



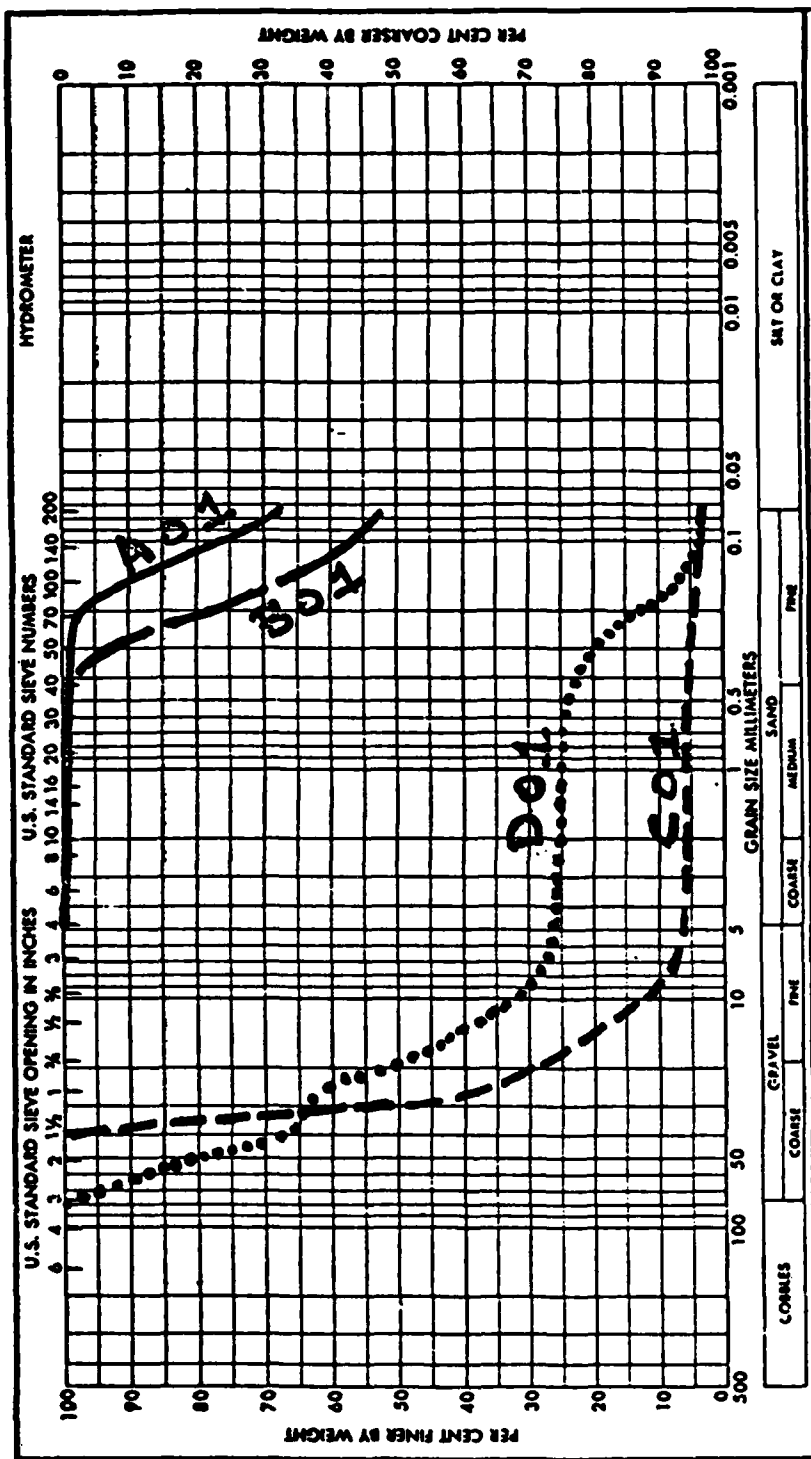
GRADATION CURVES, SEDIMENT SAMPLES FROM WILLAMETTE RIVER,
FIVE ISLAND SECONDARY CHANNEL NEAR RM 62

SIEVE ANALYSIS, SEDIMENT SAMPLES FROM WILLAMETTE RIVER, CANDIANI SIDE CHANNEL NEAR RM 58.5

U.S. Standard Sieve Size or Number	A01			B01			C01			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	--	--	--	--	--	--	--	--	--
2-in.	0	0	100.0	--	--	--	0	0	100.0	0	0	100.0
1-1/2-in.	237.0	13.99	86.0	0	0	100.0	171.0	12.44	87.6	975.0	39.54	60.5
1-in.	145.0	8.56	77.5	99.5	2.30	97.7	454.0	33.03	54.5	285.5	11.58	48.9
3/4-in.	479.2	28.29	49.2	324.0	7.50	90.2	43.0	3.13	51.4	190.0	7.70	41.2
1/2-in.	314.8	18.58	30.6	806.0	18.67	71.5	132.5	9.64	41.8	137.8	5.59	35.6
3/8-in.	174.0	10.27	20.3	614.0	14.22	57.3	24.5	1.78	40.0	110.8	4.49	31.1
No. 3	85.5	5.05	15.3	670.0	15.52	41.8	27.0	1.96	38.0	134.8	5.46	25.6
No. 4	43.2	2.55	12.7	263.0	6.09	35.7	9.2	0.67	37.3	78.8	3.19	22.5
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	46.5	2.74	10.0	244.0	5.65	30.1	18.0	1.31	36.0	126.0	5.11	17.3
No. 10	8.5	0.50	9.5	37.0	0.86	29.2	5.5	0.40	35.6	19.2	0.78	16.6
No. 16	12.5	0.74	8.7	42.5	0.98	28.2	6.5	0.47	35.2	37.0	1.50	15.1
No. 20	6.0	0.35	8.4	15.0	0.35	27.9	1.5	0.11	35.1	13.5	0.55	14.5
No. 30	10.0	0.59	7.8	25.0	0.58	27.3	0.8	0.05	35.0	11.8	0.48	14.0
No. 40	15.2	0.90	6.9	151.5	3.51	23.8	1.0	0.07	34.9	27.2	1.11	12.9
No. 50	33.5	1.98	4.9	549.0	12.71	11.1	28.2	2.06	32.9	122.0	4.95	8.0
No. 70	39.2	2.32	2.6	280.5	6.50	4.6	98.8	7.18	25.7	119.2	4.84	3.1
No. 100	27.0	1.59	1.0	146.0	3.38	1.2	150.8	10.97	14.7	58.8	2.38	0.8
No. 140	8.8	0.52	0.5	35.0	0.81	0.4	90.8	6.60	8.1	13.5	0.55	0.2
No. 200	3.8	0.22	0.3	7.5	0.17	0.2	50.0	3.64	4.5	2.8	0.11	0.1
Pan	4.5	0.27	0.0	8.5	0.20	0.0	61.5	4.47	0.0	2.5	0.10	0.0
Total Weight, grams	1694.2	--	--	4318.0	--	--	1374.5	--	--	2466.0	--	--

SIEVE ANALYSIS, SEDIMENTS SAMPLES FROM WILLAMETTE RIVER, LAMBERT SLOUGH NEAR RM 65

U.S. Standard Sieve Size or Number	A01			B01			C01			D01		
	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.	Weight Retained, grams	Percent Retained	Percent Finer by Wt.
3-in.	--	--	--	--	--	--	--	--	--	0	0	100.0
2-in.	--	--	--	--	--	--	--	--	--	434.0	18.27	81.7
1-1/2-in.	--	--	--	--	--	--	0	0	100.0	381.0	16.04	65.7
1-in.	--	--	--	--	--	--	660.5	58.66	41.3	36.2	1.53	64.2
3/4-in.	--	--	--	--	--	--	182.0	16.16	25.2	308.0	12.96	51.2
1/2-in.	--	--	--	--	--	--	91.0	8.08	17.1	272.0	11.45	39.8
3/8-in.	--	--	--	--	--	--	79.0	7.02	10.1	187.8	7.90	31.9
No. 3	--	--	--	--	--	--	35.2	3.13	7.0	92.0	3.87	28.0
No. 4	0	0	100.0	--	--	--	10.2	0.91	6.0	28.2	1.19	26.8
No. 6	--	--	--	--	--	--	--	--	--	--	--	--
No. 8	0.2	0.05	99.9	--	--	--	6.0	0.53	5.5	22.2	0.94	25.9
No. 10	0.0	0	99.9	--	--	--	0.2	0.02	5.5	5.2	0.22	25.6
No. 16	0.2	0.05	99.9	--	--	--	1.0	0.09	5.4	8.5	0.36	25.3
No. 20	0.2	0.05	99.8	--	--	--	0.5	0.04	5.4	4.5	0.19	25.1
No. 30	0.0	0.00	99.8	0	0	100.0	0.2	0.02	5.3	0.8	0.03	25.1
No. 40	0.0	0.00	99.8	2.0	0.26	99.7	1.8	0.16	5.2	30.8	1.29	23.8
No. 50	0.2	0.05	99.8	43.2	5.56	94.2	4.5	0.40	4.8	77.8	3.27	20.5
No. 70	4.2	0.92	98.9	94.0	12.07	82.1	3.2	0.29	4.5	142.8	6.01	14.5
No. 100	35.0	7.62	91.2	112.2	14.42	67.7	5.0	0.44	4.0	159.0	6.69	7.8
No. 140	63.0	13.71	77.5	75.5	9.70	58.0	5.5	0.49	3.6	73.8	3.10	4.7
No. 200	48.2	10.50	67.0	46.5	5.97	52.0	6.5	0.58	3.0	29.2	1.23	3.5
Pan	308.0	67.03	0.0	405.0	52.02	0.0	33.5	2.98	0.0	82.2	3.46	0.0
Total Weight, grams	459.5	--	--	778.5	--	--	1126.0	--	--	2376.0	--	--



GRADATION CURVES, SEDIMENT SAMPLES FROM WILLAMETTE RIVER,

LAMBERT SLOUGH NEAR RM 65

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